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DeBerry et al.

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(54) **SYSTEMS AND METHODS FOR RISER COUPLING**

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Related U.S. Application Data

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(51) **Int. Cl.**

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E21B 19/06	(2006.01)
E21B 19/16	(2006.01)
E21B 17/01	(2006.01)
E21B 17/046	(2006.01)
E21B 19/00	(2006.01)
E21B 19/10	(2006.01)
E21B 19/24	(2006.01)

(52) **U.S. Cl.**
CPC ***E21B 19/165*** (2013.01); ***E21B 17/01*** (2013.01); ***E21B 17/046*** (2013.01); ***E21B 17/085*** (2013.01); ***E21B 19/002*** (2013.01); ***E21B 19/06*** (2013.01); ***E21B 19/10*** (2013.01); ***E21B 19/16*** (2013.01); ***E21B 19/24*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 17/085
USPC 166/344, 360, 367, 379, 77.51, 85.1; 285/922; 405/169, 170
See application file for complete search history.

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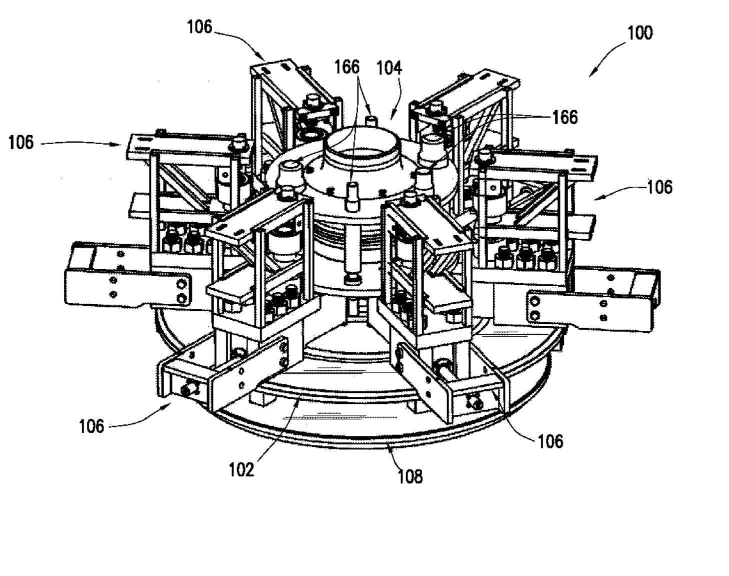
(57) **ABSTRACT**

Systems and methods for riser coupling are disclosed. A riser coupling system comprises a riser joint connector comprising a first tubular assembly coupled to a second tubular assembly. The riser coupling system further comprises a spider assembly which receives the riser joint connector and has a connector actuation tool. The connector actuation tool comprises a dog assembly, a clamping tool and a splined member. The dog assembly selectively extends a dog to engage the riser joint connector. The clamping tool couples the first tubular assembly and the second tubular assembly. Finally, the splined member actuates a locking member of the riser joint connector.

20 Claims, 21 Drawing Sheets



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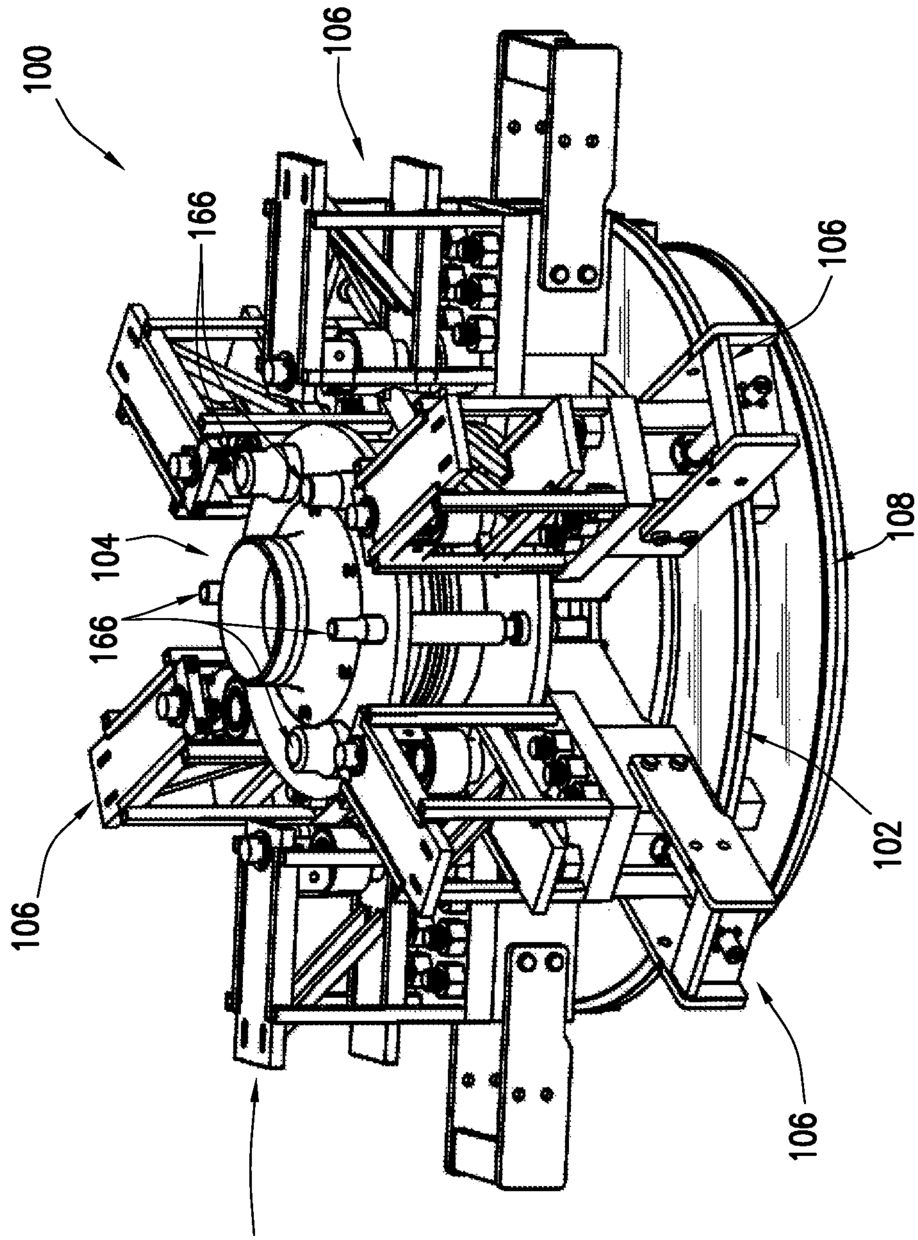

FIG. 1A

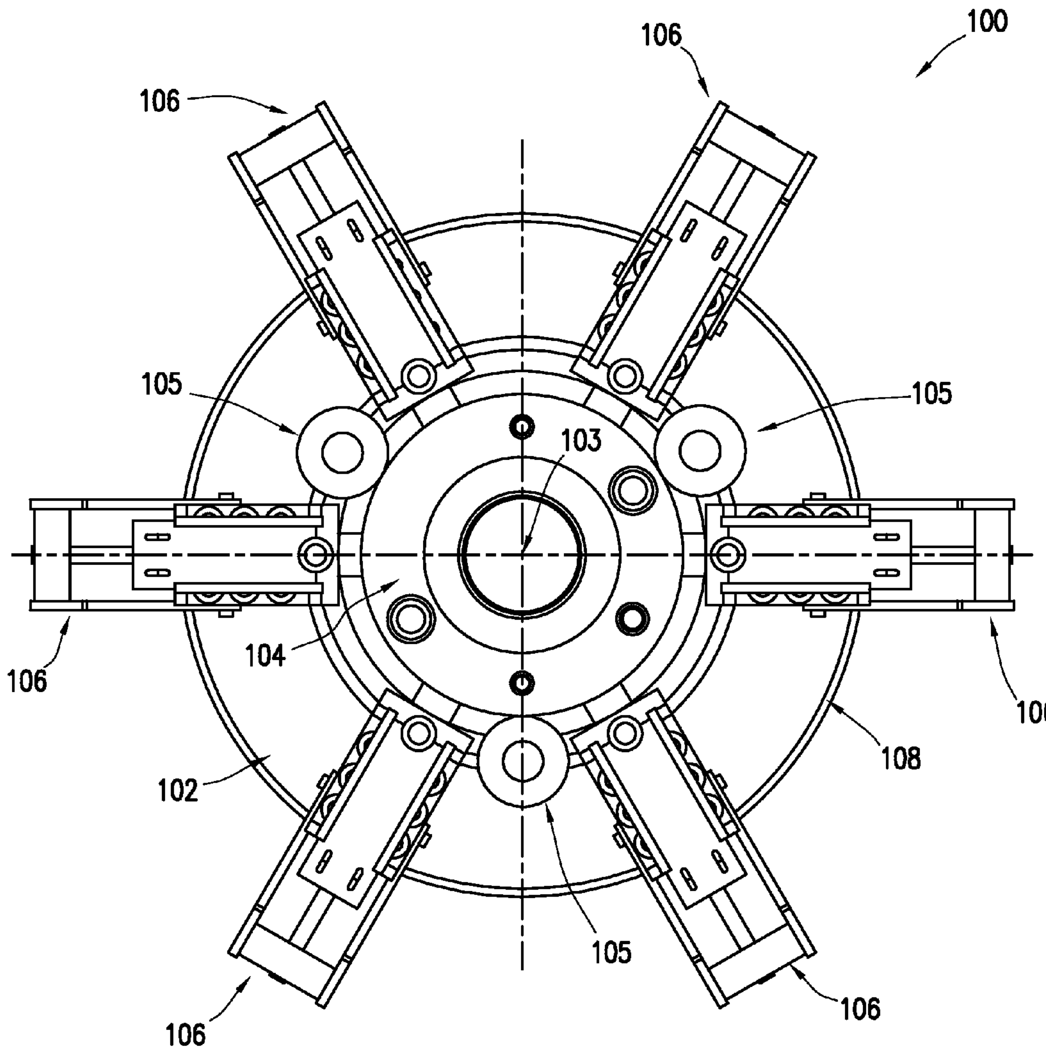

FIG.1B

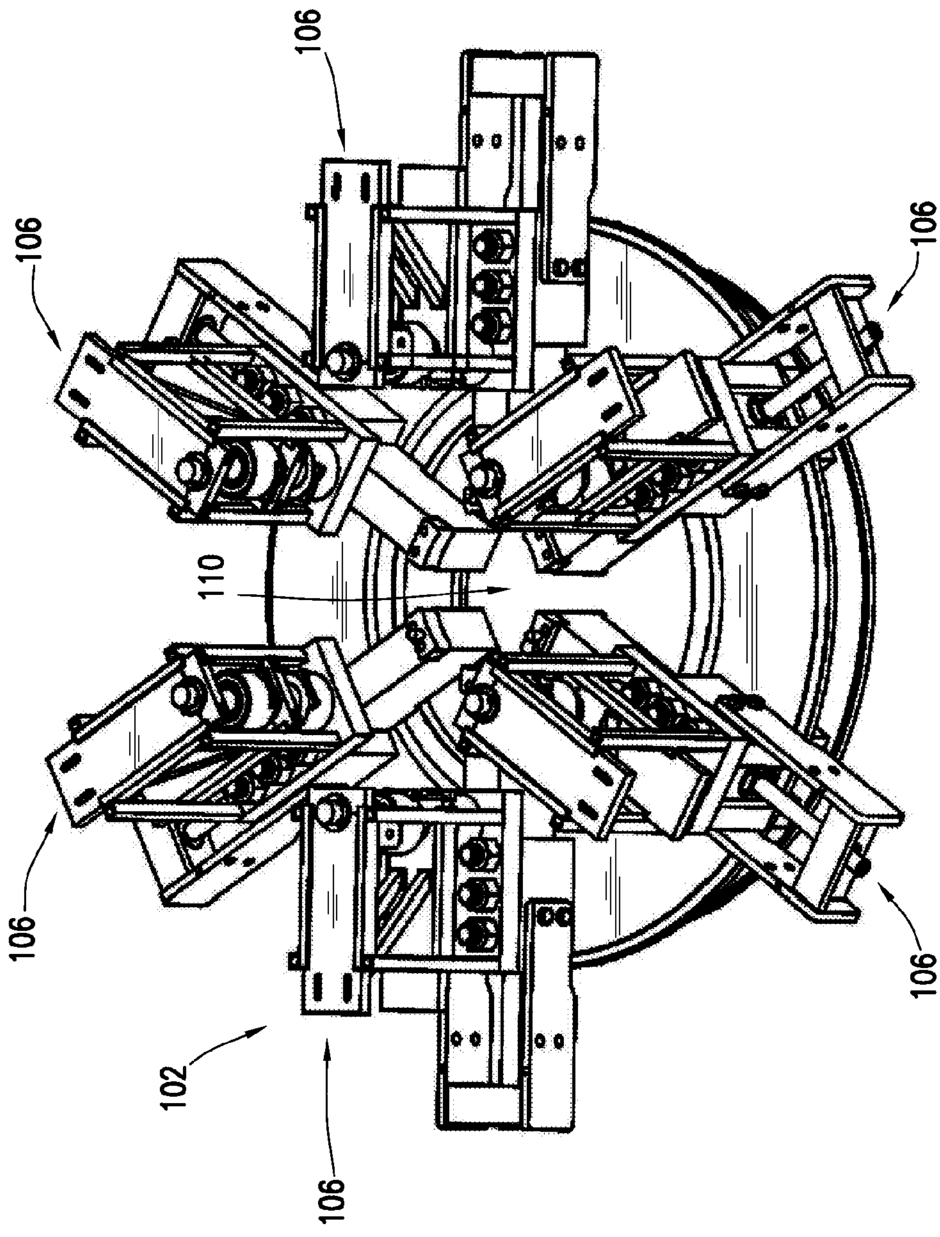

FIG.2

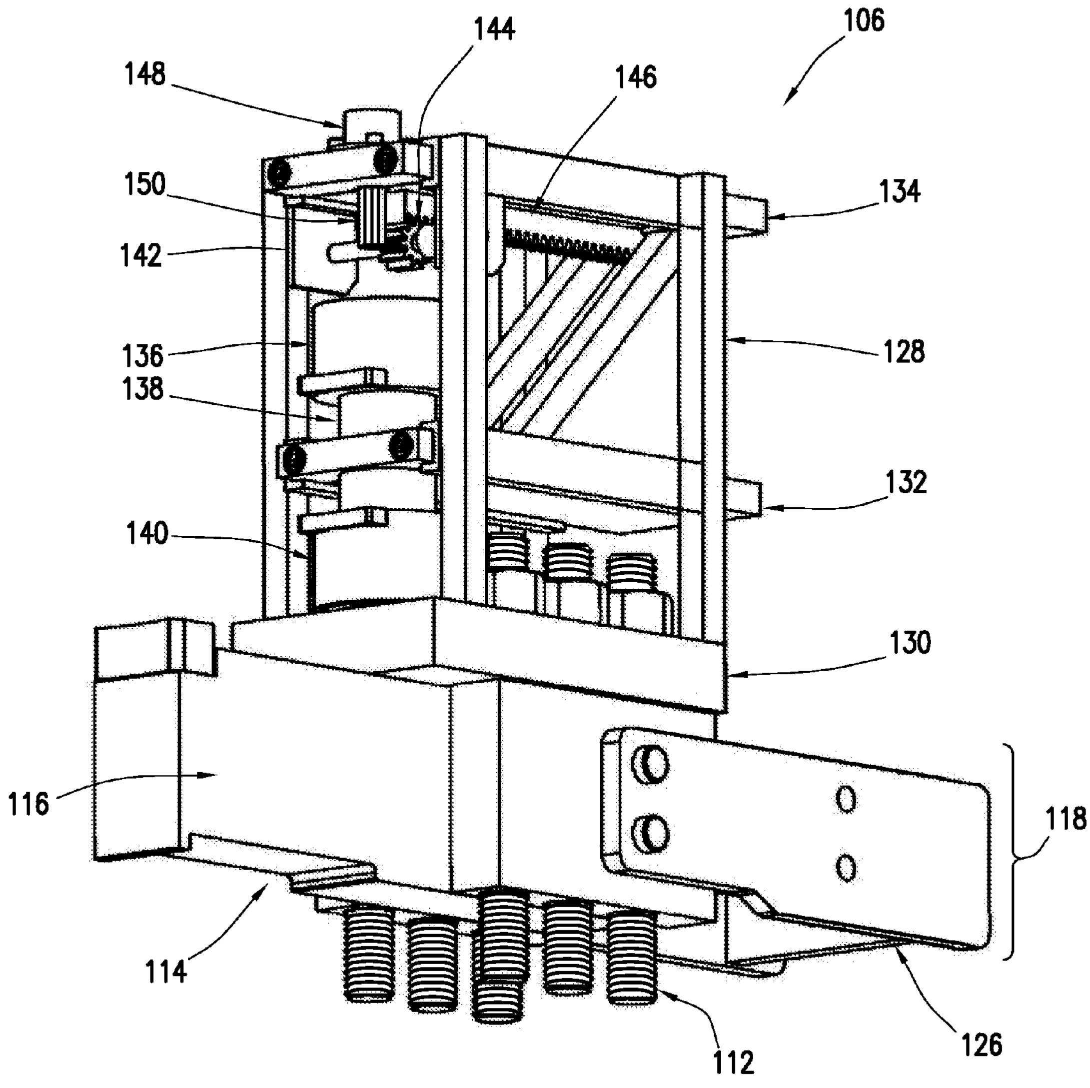
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FIG.3A

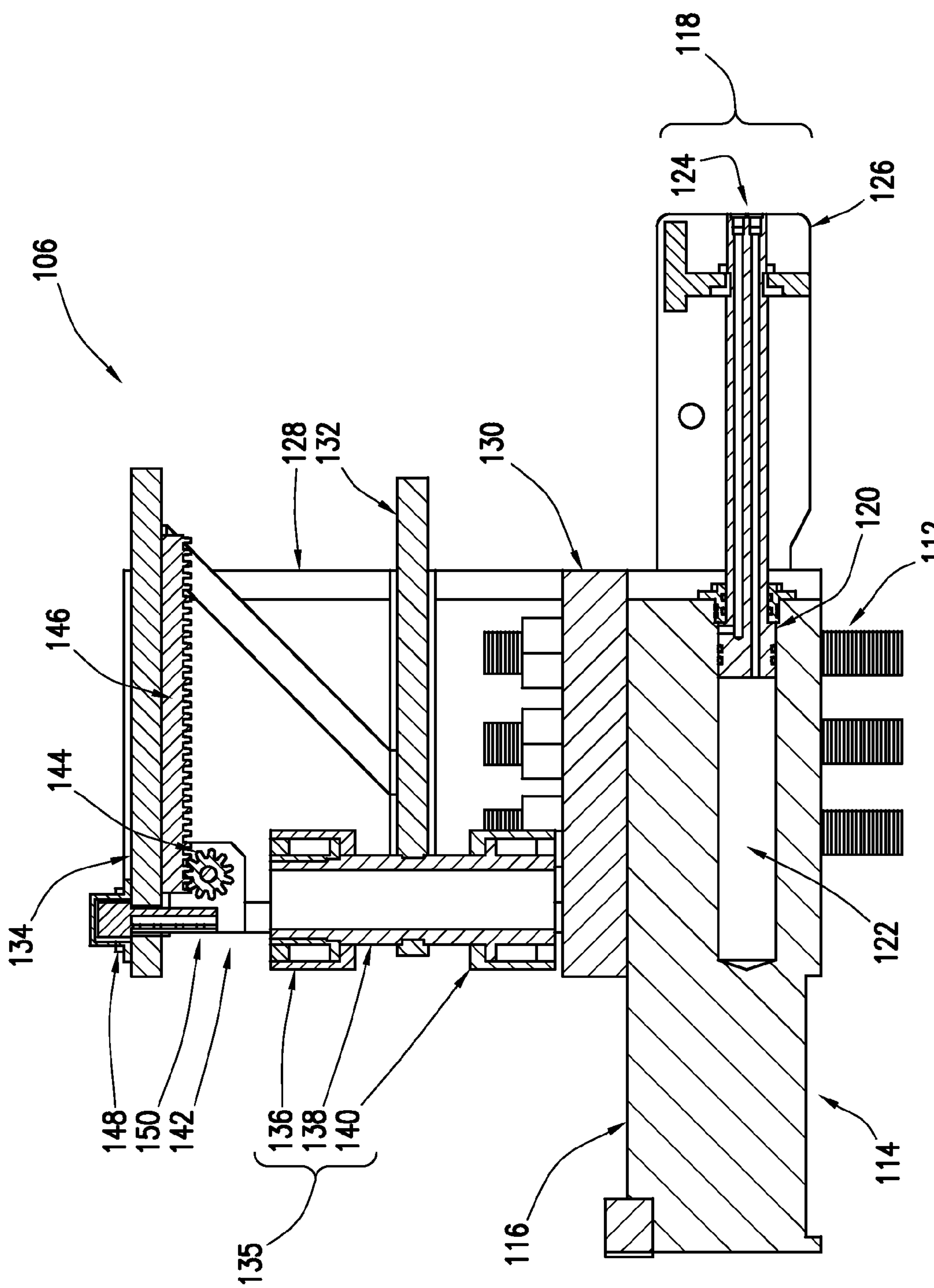
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FIG.3B

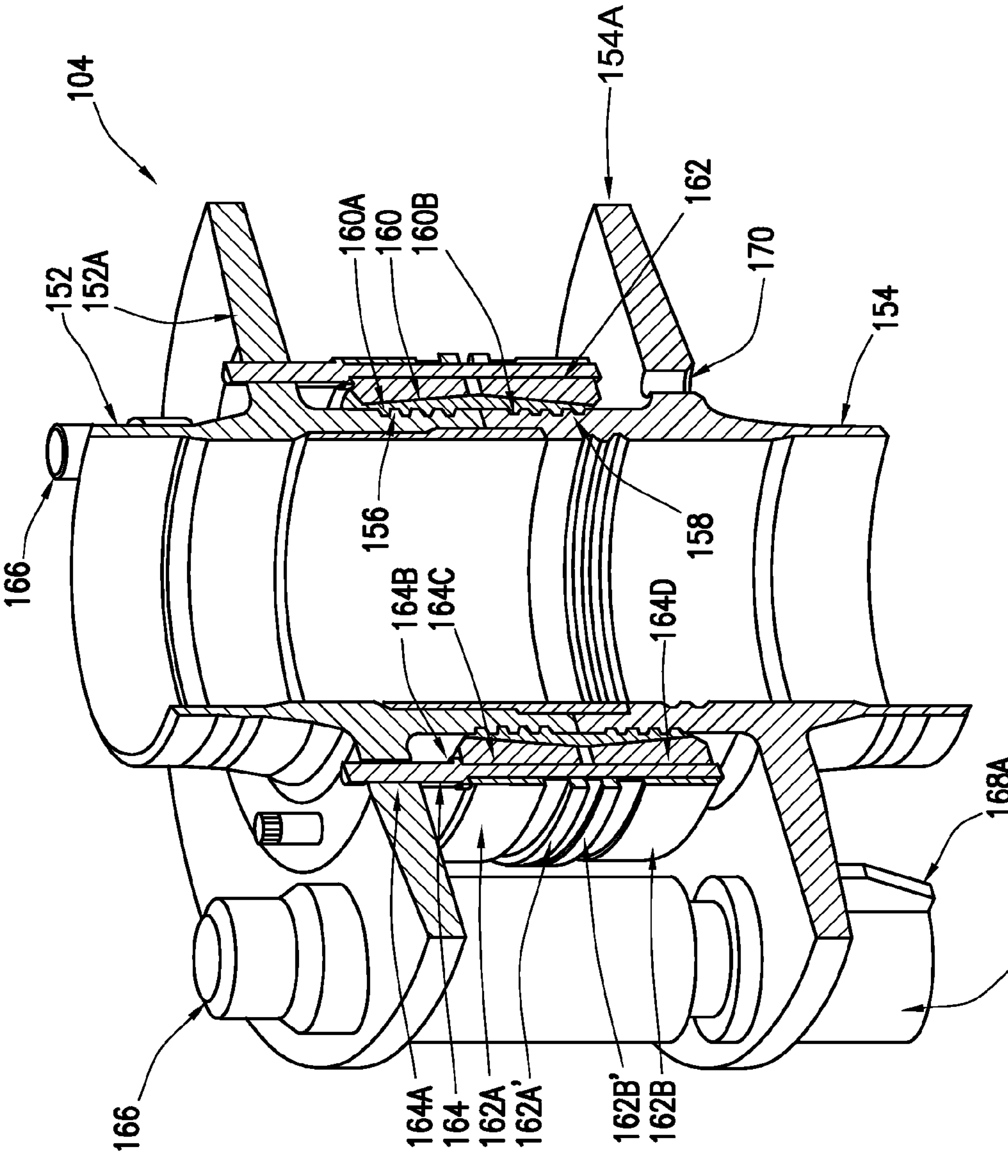
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FIG.4

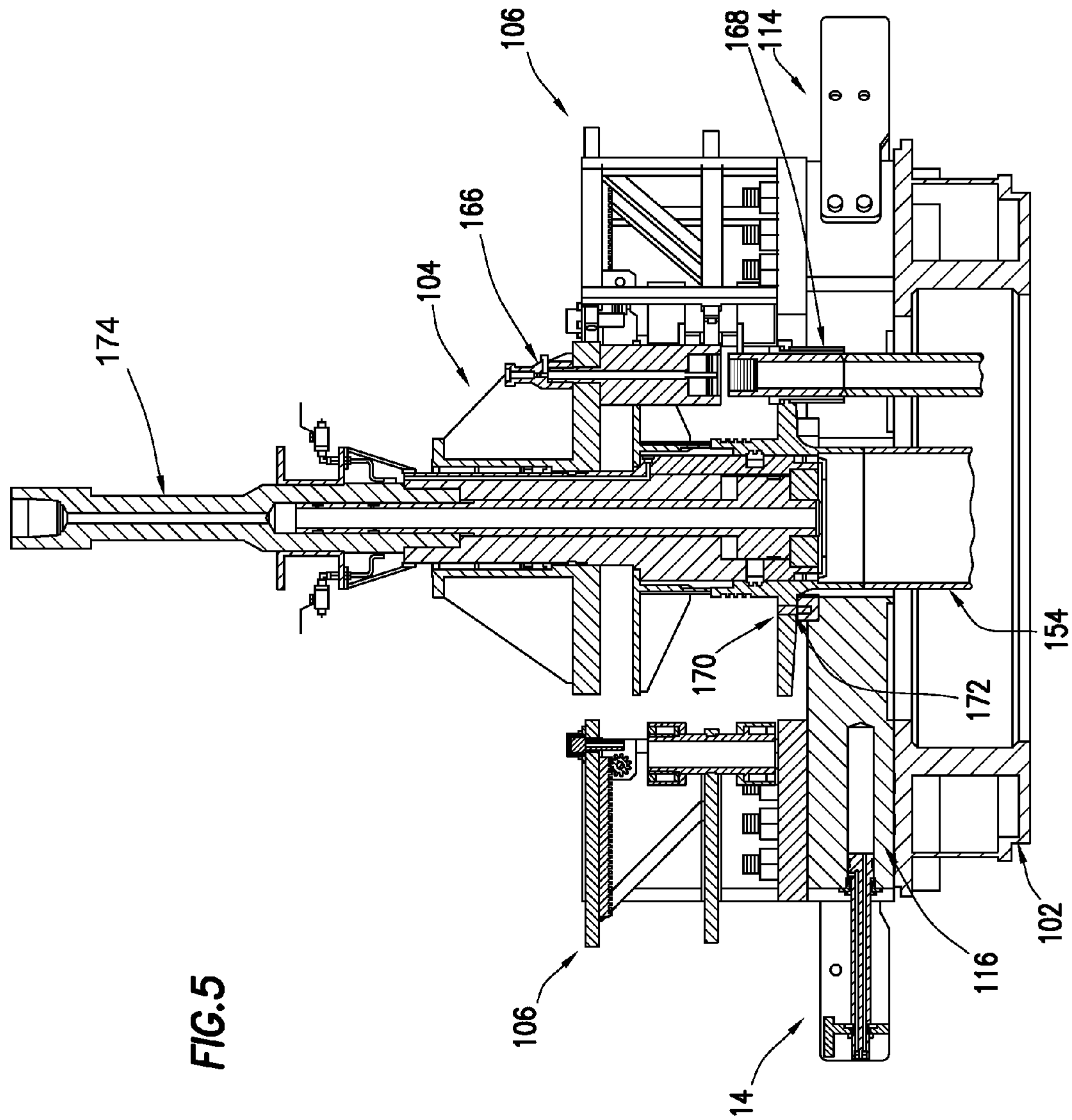

FIG.5

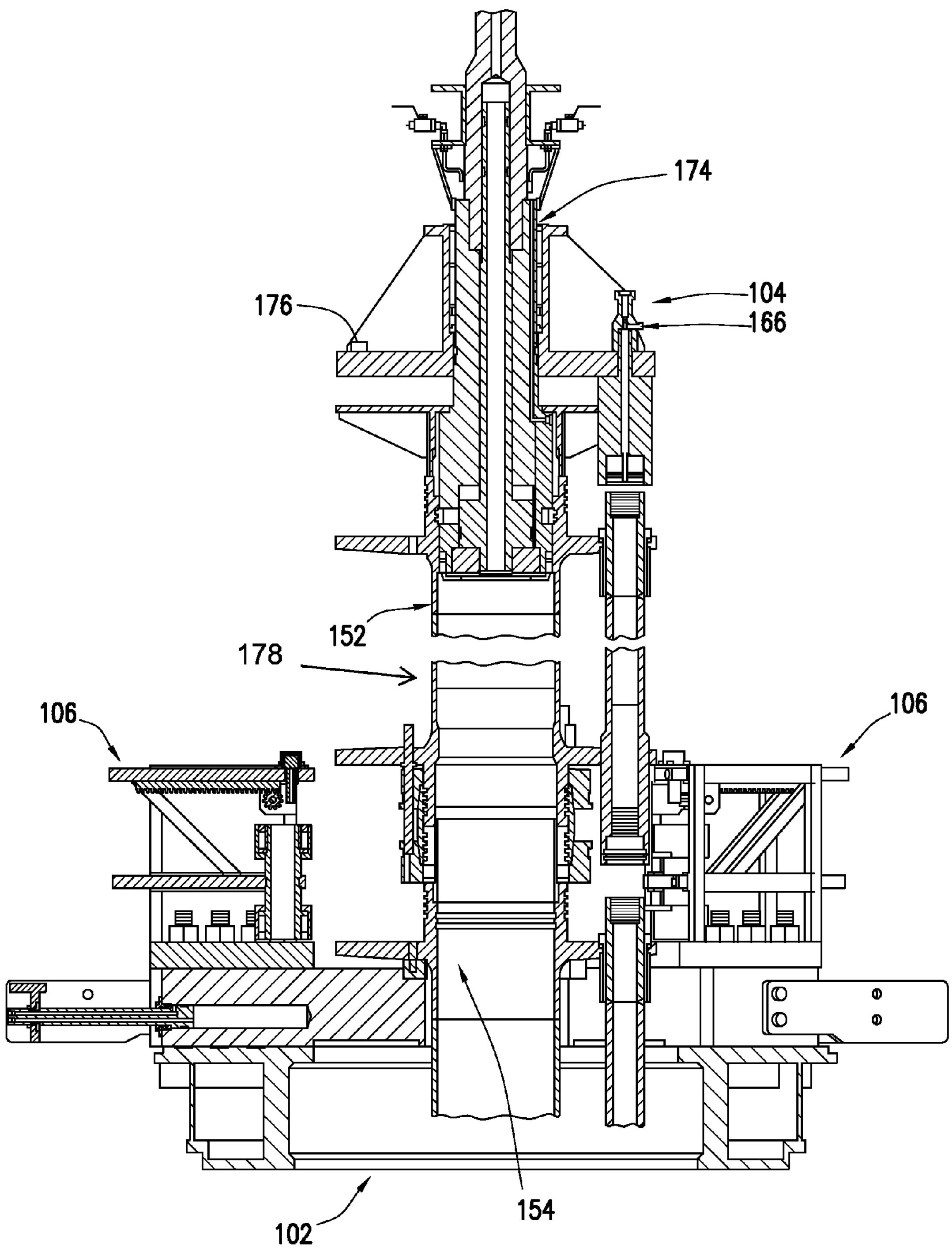

FIG.6

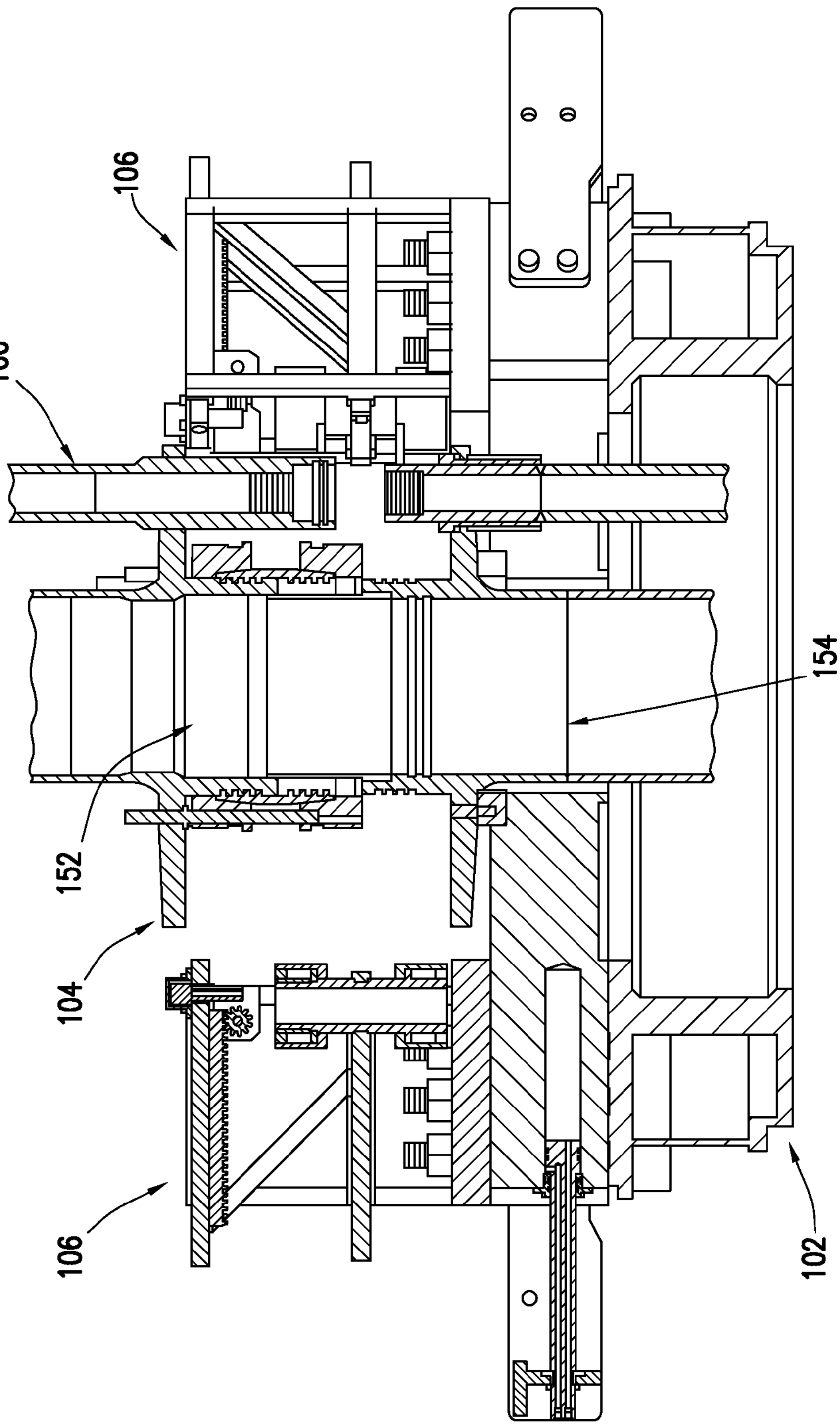

FIG.7

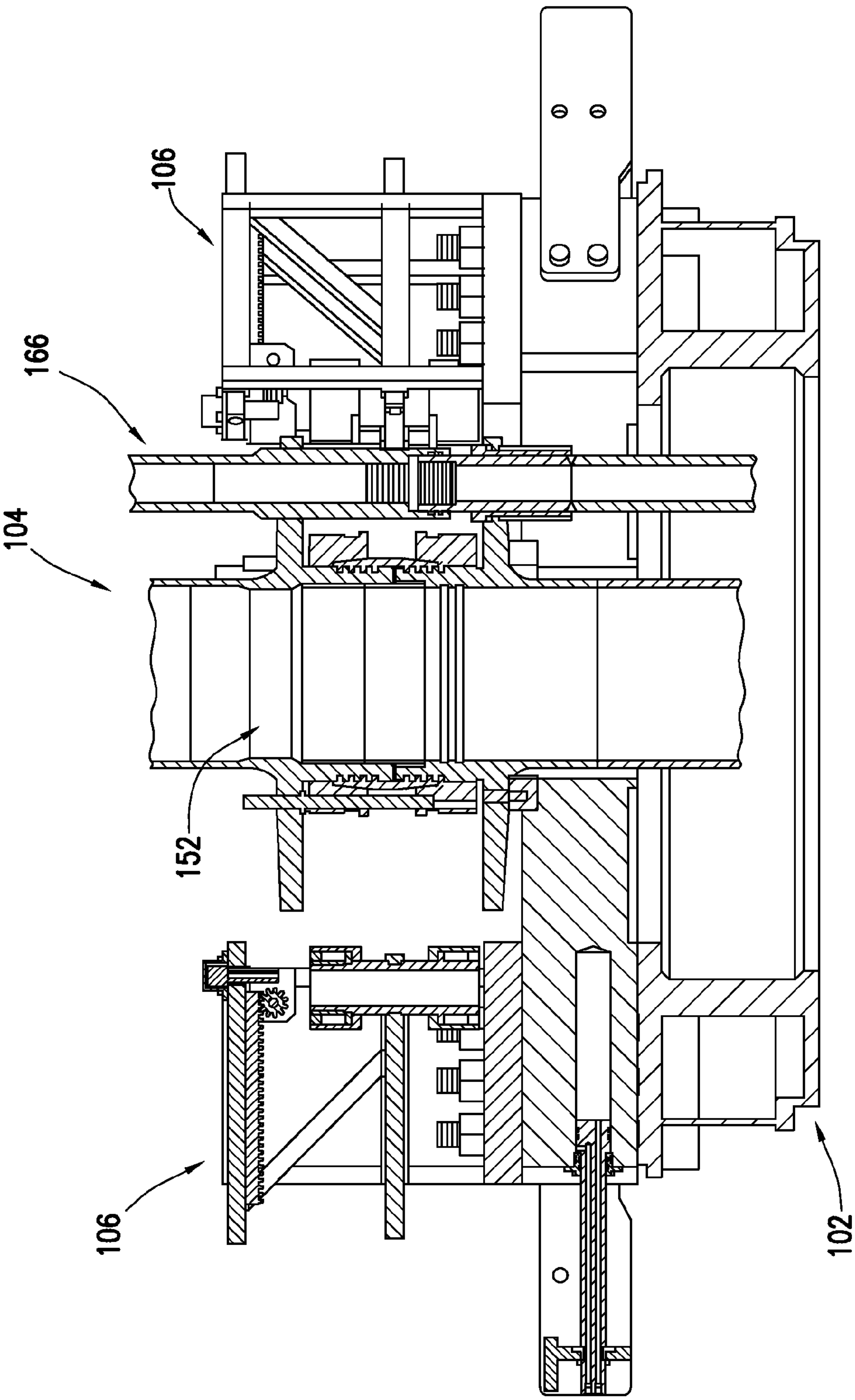

FIG.8

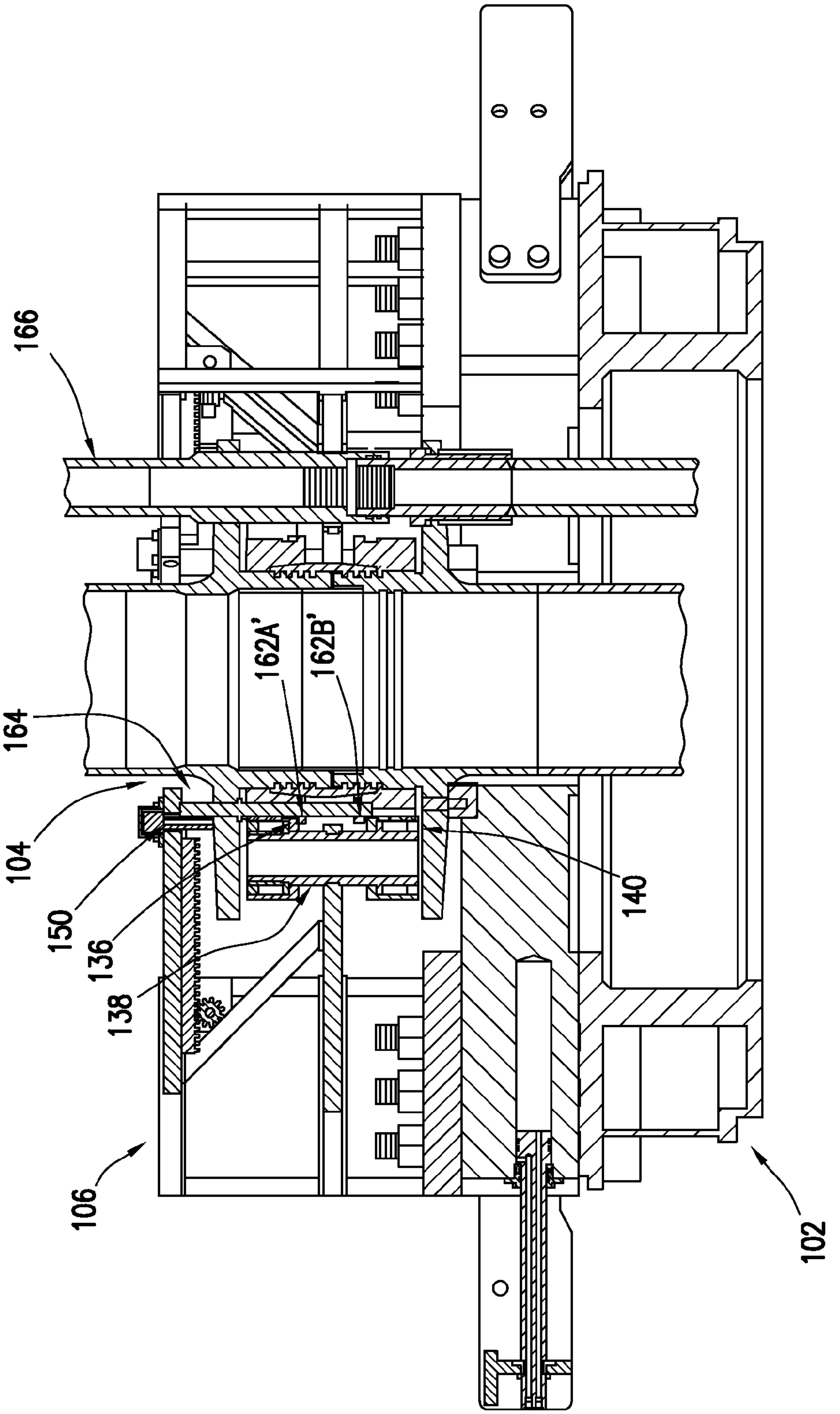

FIG.9

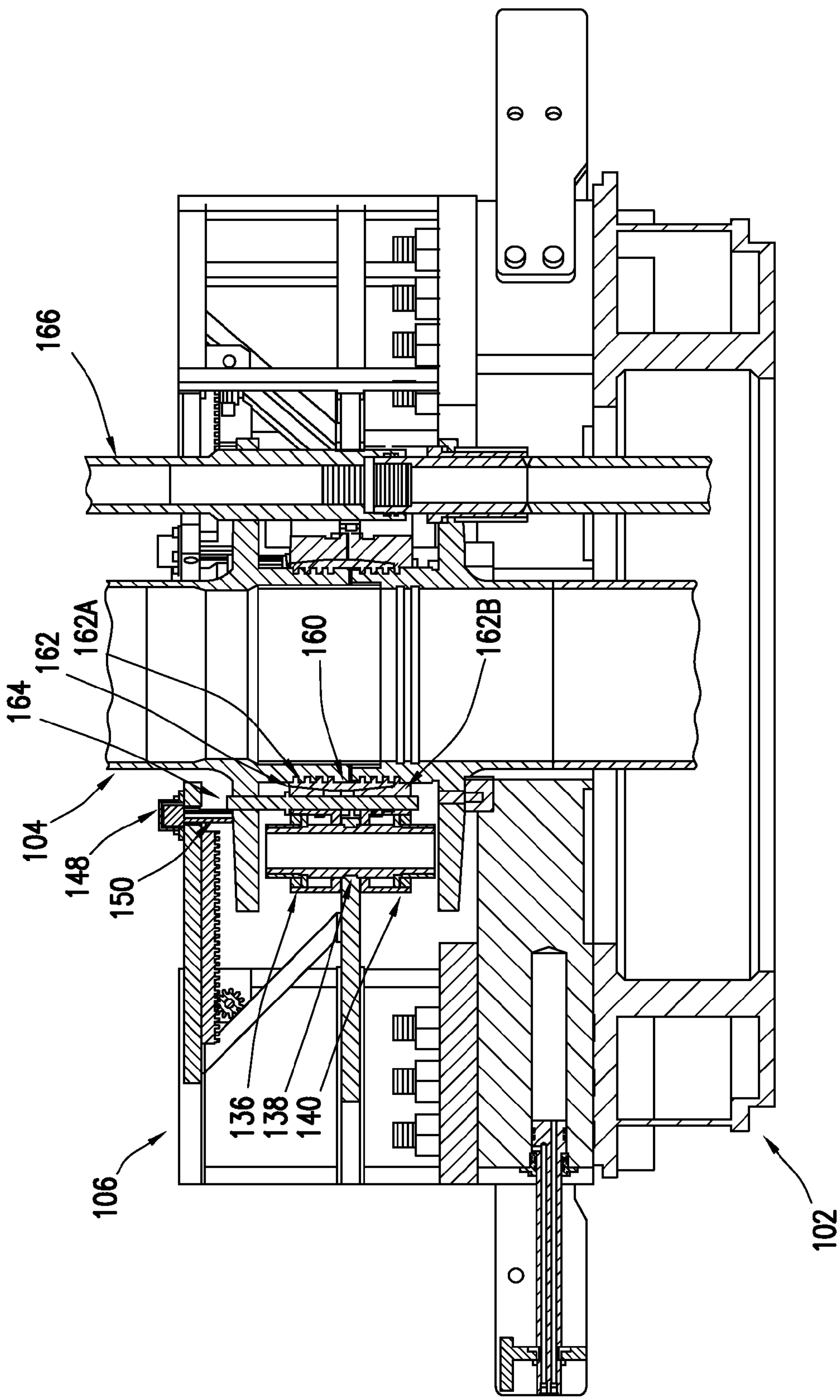

FIG.10

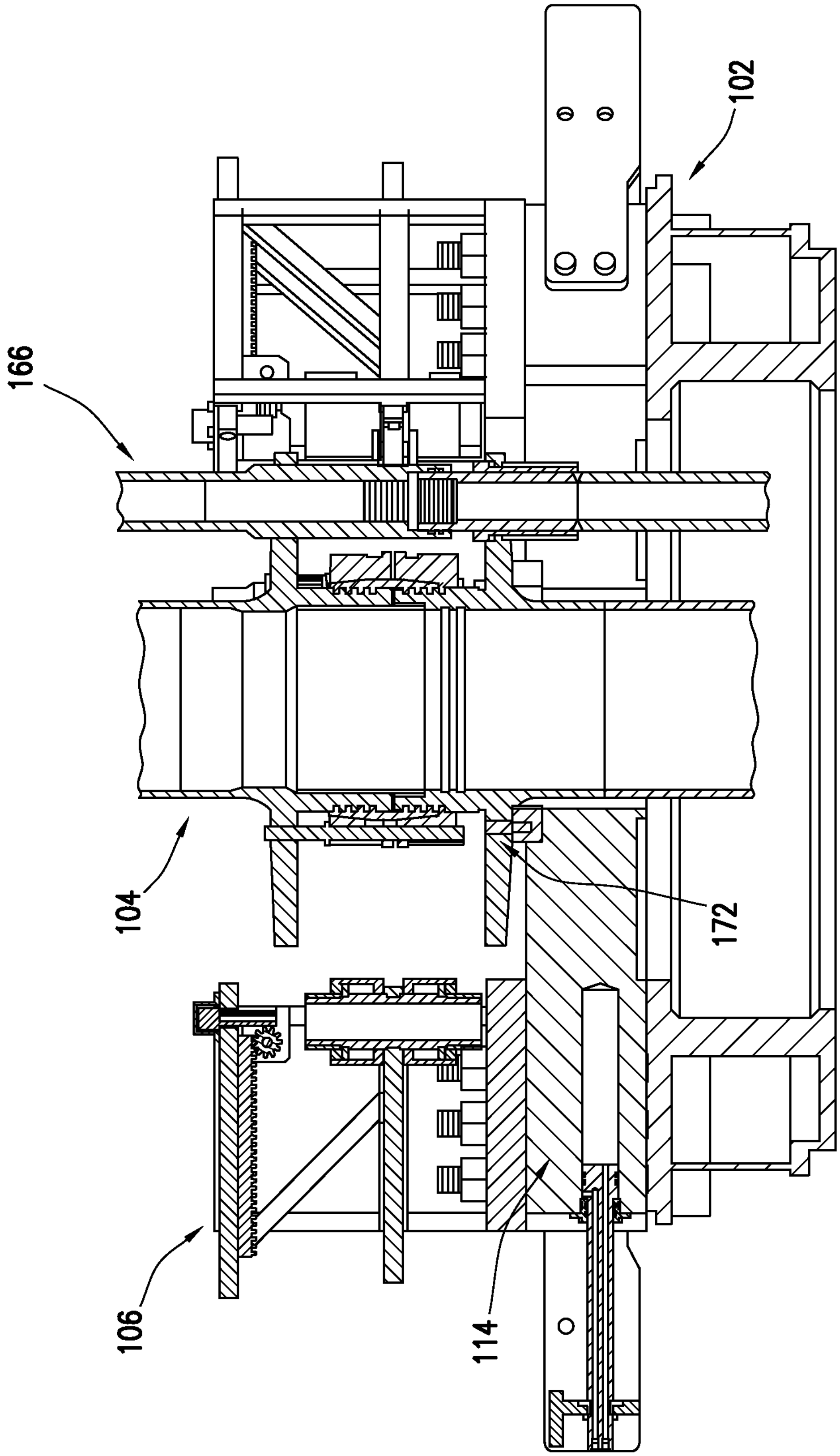

FIG.11

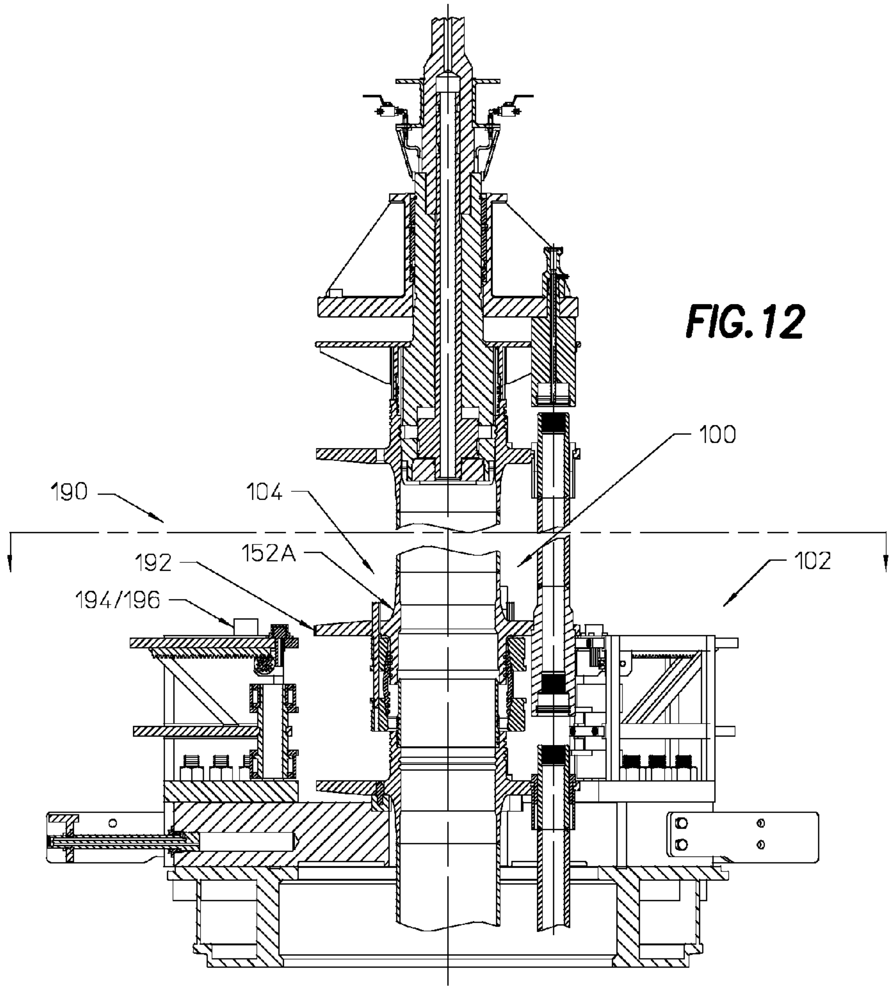

FIG. 12

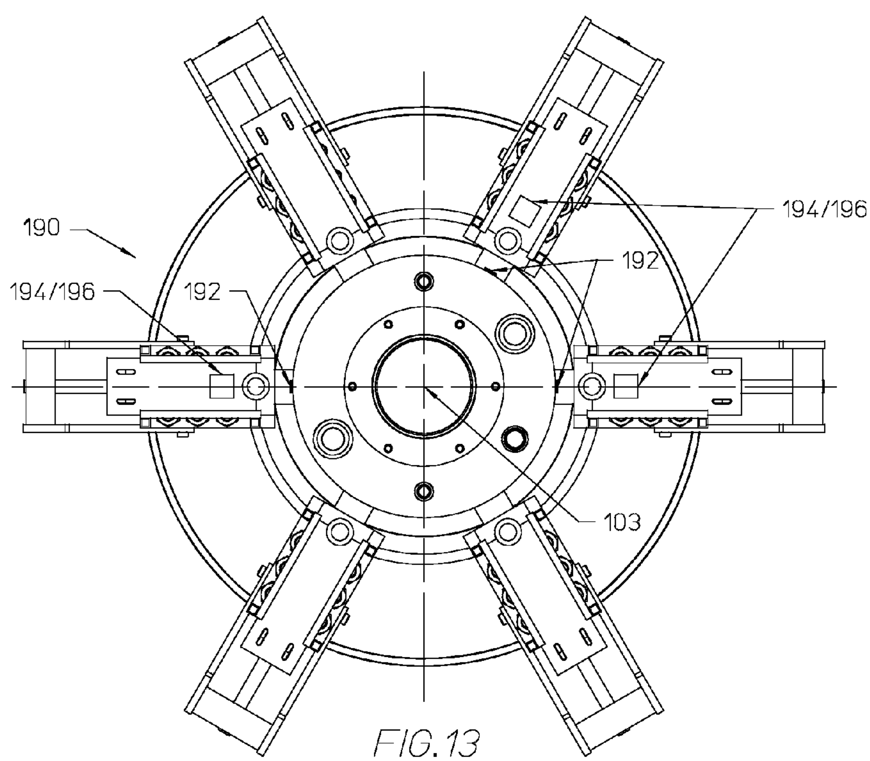

FIG. 13

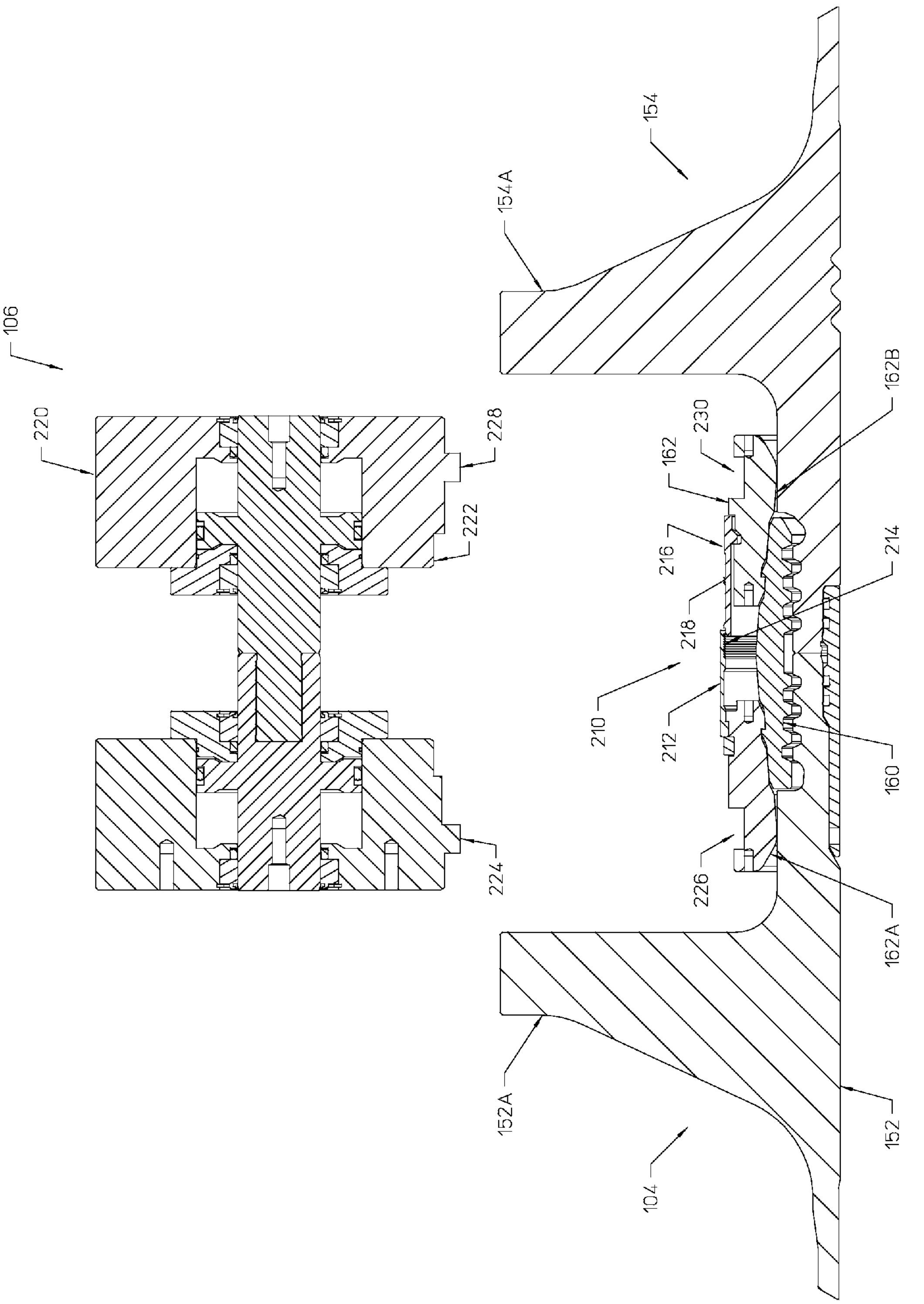
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FIG. 14A

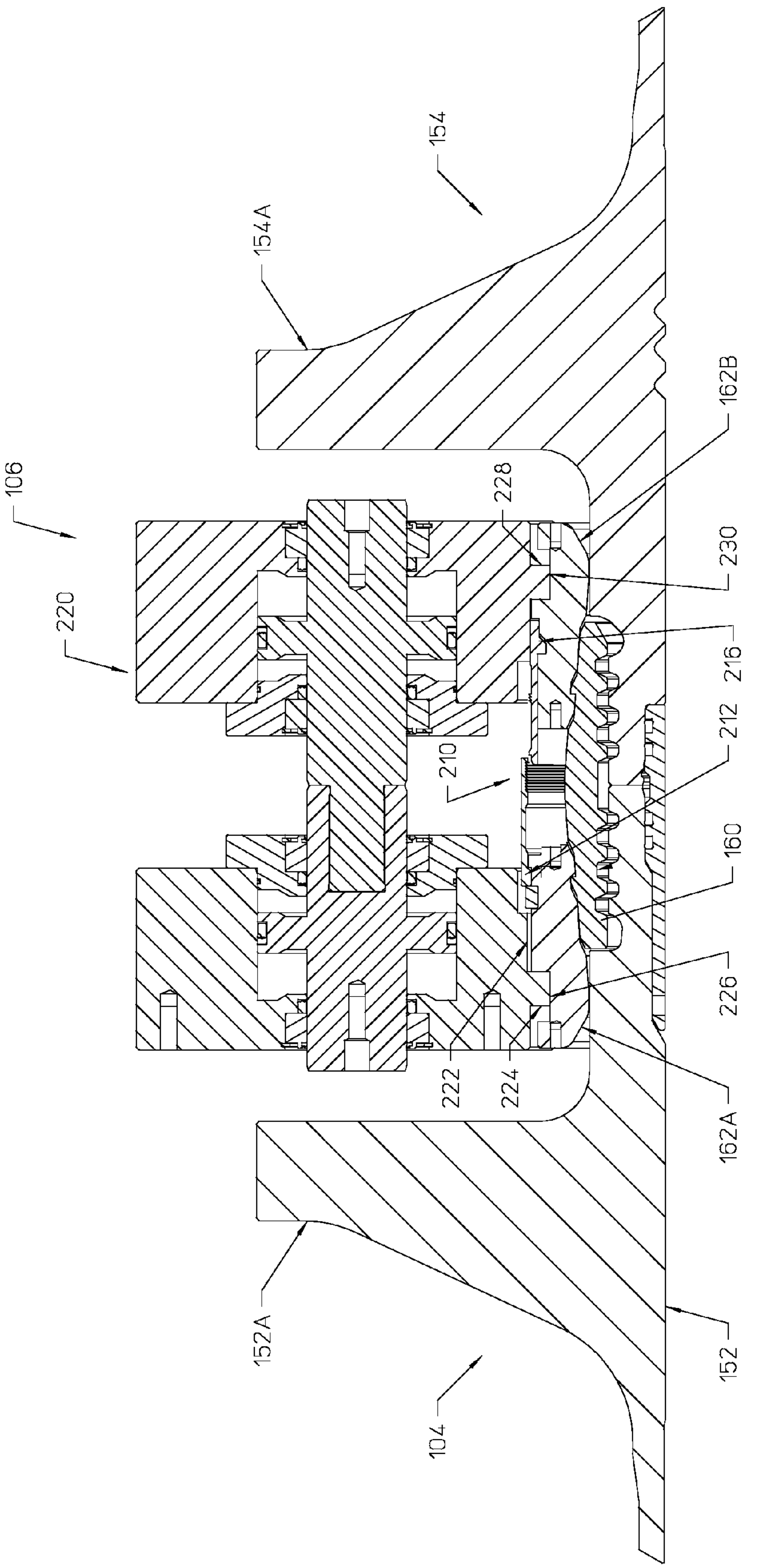
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FIG. 14B

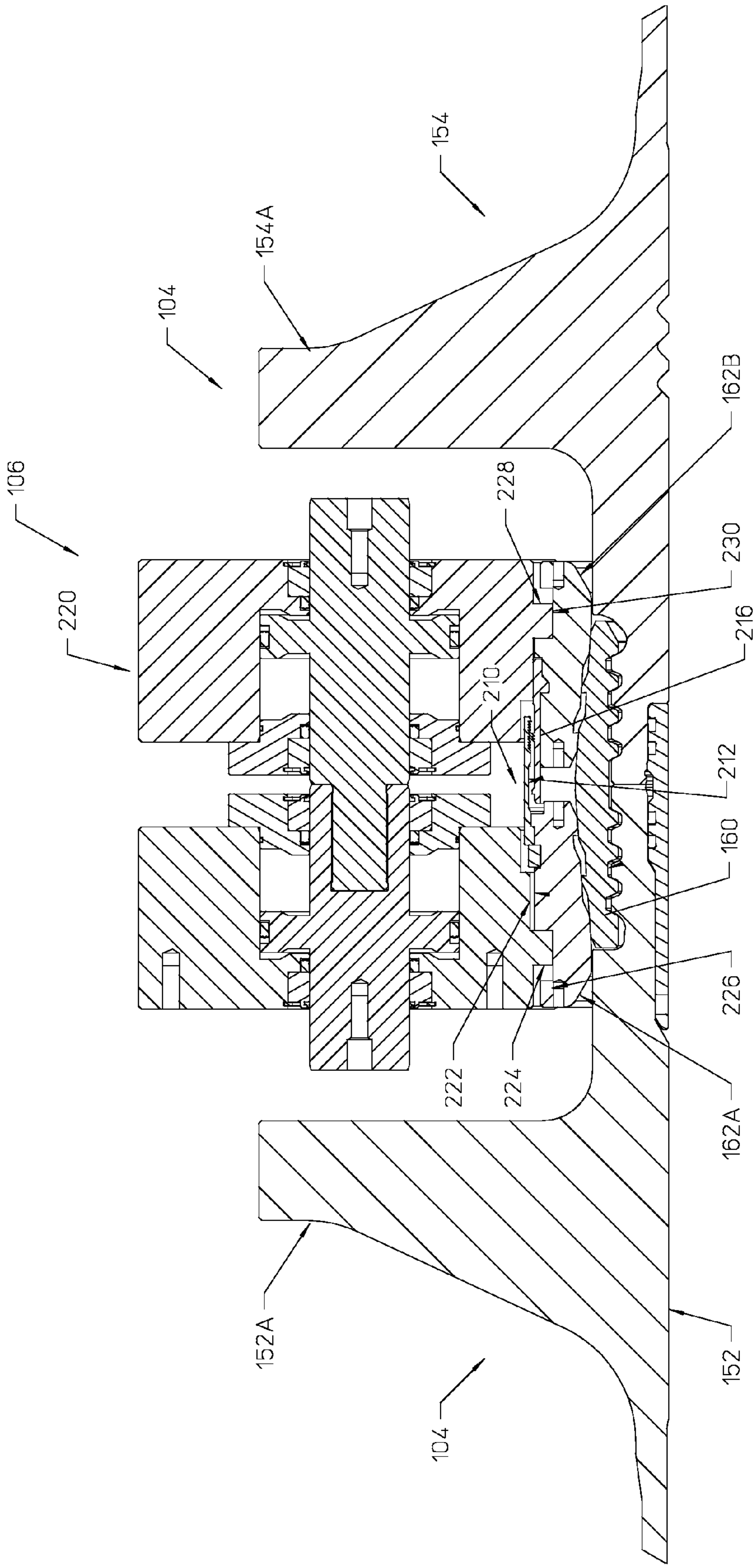
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FIG. 14C

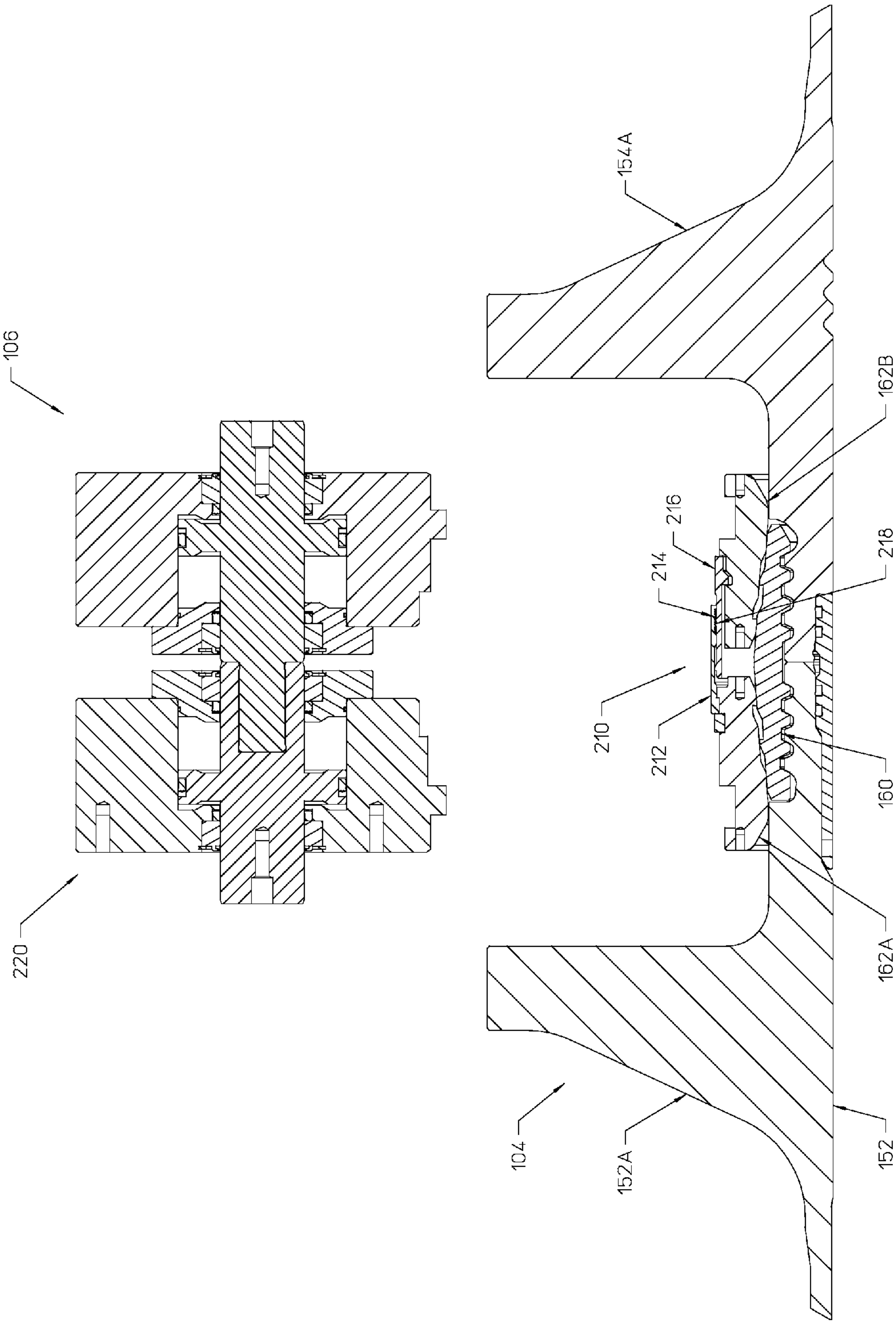

FIG. 14D

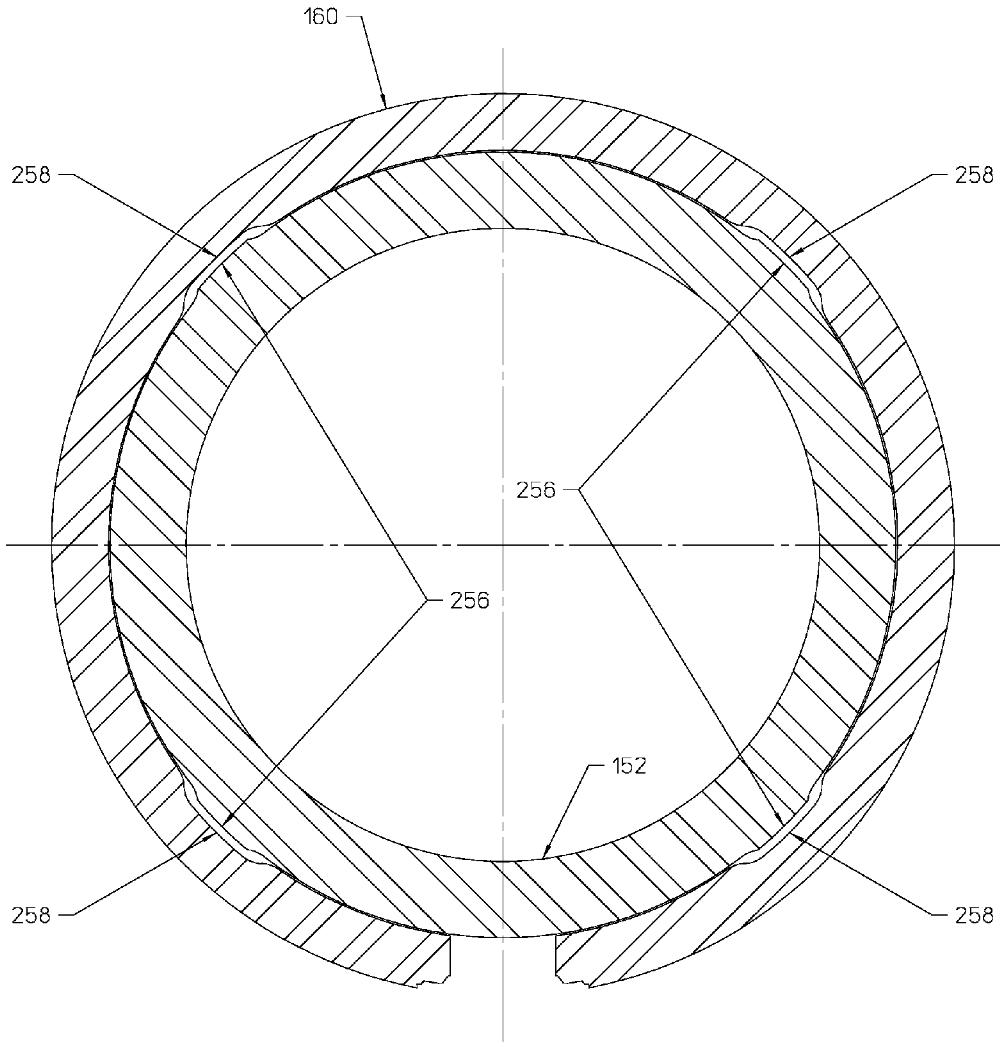

FIG. 15

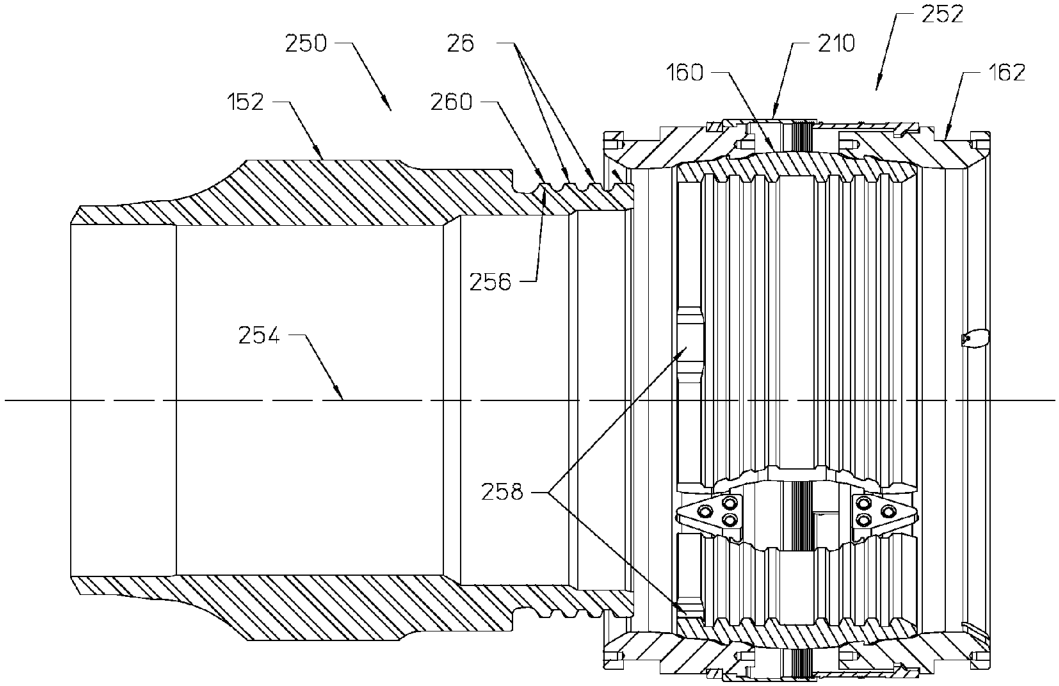

FIG. 16A

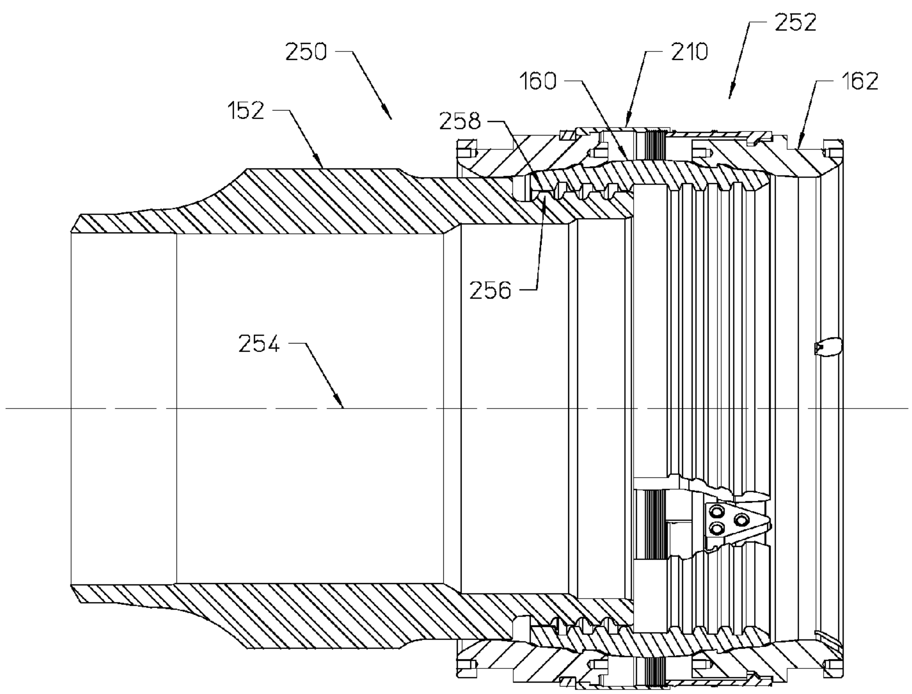

FIG. 16B

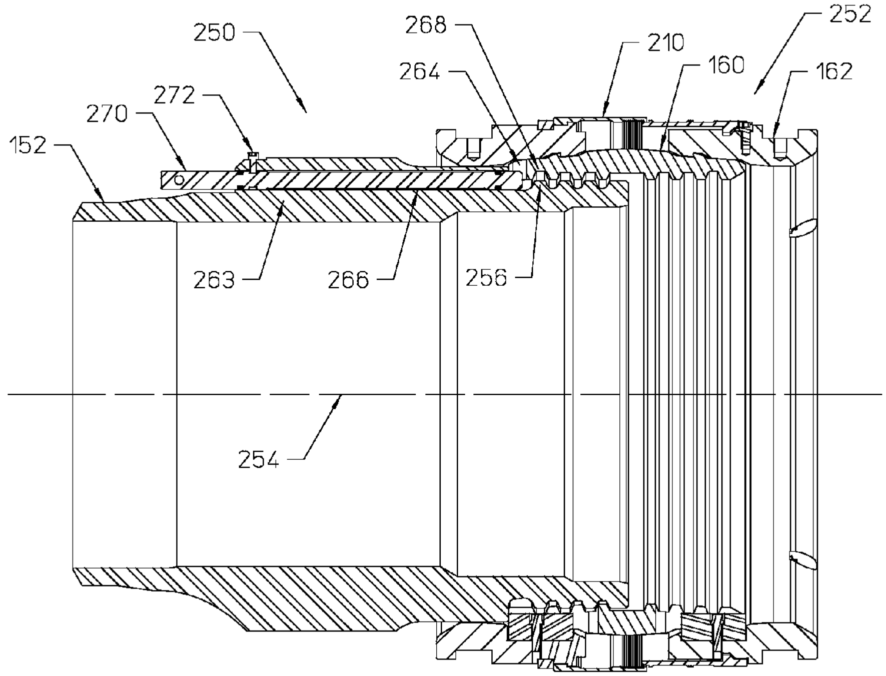

FIG. 16C

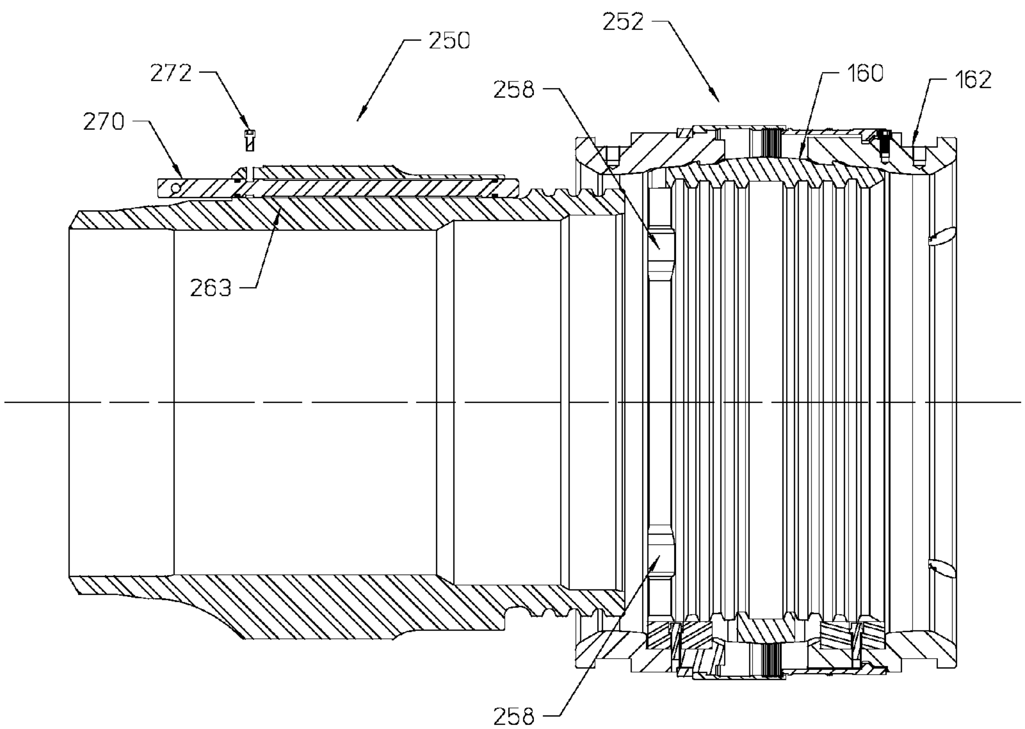

FIG. 16D

SYSTEMS AND METHODS FOR RISER COUPLING

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation in part of U.S. patent application Ser. No. 13/892,823, entitled "Systems and Methods for Riser Coupling", filed on May 13, 2013, which claimed the benefit of provisional application Ser. No. 61/646,847, entitled "Systems and Methods for Riser Coupling", filed on May 14, 2012.

BACKGROUND

The present disclosure relates generally to well risers and, more particularly, to systems and methods for riser coupling.

In drilling or production of an offshore well, a riser may extend between a vessel or platform and the wellhead. The riser may be as long as several thousand feet, and may be made up of successive riser sections. Riser sections with adjacent ends may be connected on board the vessel or platform, as the riser is lowered into position. Auxiliary lines, such as choke, kill, and/or boost lines, may extend along the side of the riser to connect with the wellhead, so that fluids may be circulated downwardly into the wellhead for various purposes. Connecting riser sections in end-to-end relation includes aligning axially and angularly two riser sections, including auxiliary lines, lowering a tubular member of an upper riser section onto a tubular member of a lower riser section, and locking the two tubular members to one another to hold them in end-to-end relation.

The riser section connecting process may require significant operator involvement that may expose the operator to risks of injury and fatigue. For example, the repetitive nature of the process over time may create a risk of repetitive motion injuries and increasing potential for human error. Moreover, the riser section connecting process may involve heavy components and may be time-intensive. Therefore, there is a need in the art to improve the riser section connecting process and address these issues.

BRIEF DESCRIPTION OF THE DRAWINGS

Some specific exemplary embodiments of the disclosure may be understood by referring, in part, to the following description and the accompanying drawings.

FIG. **1**A shows an angular view of one exemplary riser coupling system, in accordance with certain embodiments of the present disclosure.

FIG. **1**B shows a top view of a riser coupling system, in accordance with certain embodiments of the present disclosure.

FIG. **2** shows a top elevational view of a spider assembly prior to receiving a connector assembly, in accordance with certain embodiments of the present disclosure.

FIG. **3**A shows a side elevational view of one exemplary connector actuation tool, in accordance with certain embodiments of the present disclosure.

FIG. **3**B shows a cross-sectional view of a connector actuation tool, in accordance with certain embodiments of the present disclosure.

FIG. **4** shows a partially cut-away side elevational view of a connector assembly, in accordance with certain embodiments of the present disclosure.

FIG. **5** shows a cross-sectional view of landing a riser section, which may include the lower tubular assembly, in the spider assembly, in accordance with certain embodiments of the present disclosure.

FIG. **6** shows a cross-sectional view of running the upper tubular assembly to the landed lower tubular assembly, in accordance with certain embodiments of the present disclosure.

FIG. **7** shows a cross-sectional view of orienting an upper tubular assembly with respect to a lower tubular assembly, in accordance with certain embodiments of the present disclosure.

FIG. **8** shows a cross-sectional view of an upper tubular assembly landed, in accordance with certain embodiments of the present disclosure.

FIG. **9** shows a cross-sectional view of the connector actuation tool engaging a riser joint prior to locking a riser joint, in accordance with certain embodiments of the present disclosure.

FIG. **10** shows a cross-sectional view of a connector actuation tool locking a riser joint, in accordance with certain embodiments of the present disclosure.

FIG. **11** shows a cross-sectional view of the connector actuation tool retracted, in accordance with certain embodiments of the present disclosure.

FIG. **12** shows a schematic view of an orientation system for aligning a riser joint within a riser coupling system, in accordance with certain embodiments of the present disclosure.

FIG. **13** shows a schematic view of a section of a riser joint with multiple RFID tags positioned thereon, in accordance with certain embodiments of the present disclosure.

FIGS. **14**A-**14**D show a cross-sectional view of a connector actuation tool being used to lock a connector assembly with a secondary lock, in accordance with certain embodiments of the present disclosure.

FIG. **15** shows a cross-sectional view of an interface between a riser joint and a removable connector assembly, in accordance with certain embodiments of the present disclosure.

FIGS. **16**A-**16**D show cross-sectional views of a riser joint being selectively engaged and disengaged with a removable connector assembly, in accordance with certain embodiments of the present disclosure.

While embodiments of this disclosure have been depicted and described and are defined by reference to exemplary embodiments of the disclosure, such references do not imply a limitation on the disclosure, and no such limitation is to be inferred. The subject matter disclosed is capable of considerable modification, alteration, and equivalents in form and function, as will occur to those skilled in the pertinent art and having the benefit of this disclosure. The depicted and described embodiments of this disclosure are examples only, and not exhaustive of the scope of the disclosure.

DETAILED DESCRIPTION

The present disclosure relates generally to well risers and, more particularly, to systems and methods for riser coupling.

Illustrative embodiments of the present disclosure are described in detail herein. In the interest of clarity, not all features of an actual implementation may be described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation specific decisions must be made to achieve the specific implementation goals, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of the present disclosure. To facilitate a better understanding of the present disclosure, the following examples of certain embodiments are given. In no way should the following examples be read to limit, or define, the scope of the disclosure.

For purposes of this disclosure, an information handling system may include any instrumentality or aggregate of instrumentalities operable to compute, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, an information handling system may be a personal computer, a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price. The information handling system may include random access memory (RAM), one or more processing resources such as a central processing unit (CPU) or hardware or software control logic, ROM, and/or other types of nonvolatile memory. Additional components of the information handling system may include one or more disk drives, one or more network ports for communication with external devices as well as various input and output (I/O) devices, such as a keyboard, a mouse, and a video display. The information handling system may also include one or more buses operable to transmit communications between the various hardware components.

For the purposes of this disclosure, computer-readable media may include any instrumentality or aggregation of instrumentalities that may retain data and/or instructions for a period of time. Computer-readable media may include, for example, without limitation, storage media such as a direct access storage device (e.g., a hard disk drive or floppy disk drive), a sequential access storage device (e.g., a tape disk drive), compact disk, CD-ROM, DVD, RAM, ROM, electrically erasable programmable read-only memory (EEPROM), and/or flash memory; as well as communications media such wires, optical fibers, microwaves, radio waves; and/or any combination of the foregoing.

For the purposes of this disclosure, a sensor may include any suitable type of sensor, including but not limited to optical, radio frequency, acoustical, pressure, torque, or proximity sensors.

FIG. **1**A shows an angular view of one exemplary riser coupling system **100**, in accordance with certain embodiments of the present disclosure. FIG. **1**B shows a top view of the riser coupling system **100**. The riser coupling system **100** may include a spider assembly **102** adapted to one or more of receive, at least partially orient, engage, hold, and actuate a riser joint connector **104**. The spider assembly **102** may include one or more connector actuation tools **106**. In certain embodiments, a plurality of connector actuation tools **106** may be spaced radially about an axis **103** of the spider assembly **102**. By way of nonlimiting example, two connector actuation tools **106** may be disposed around a circumference of the spider assembly **102** in an opposing placement. The nonlimiting example of FIG. **1** show three pairs of opposing connector actuation tools **106**. It should be understood that various embodiments may include any suitable number of connector actuation tools **106**.

As depicted in FIG. **1**B, certain embodiments may include one or more orienting members **105** disposed radially about the axis **103** to facilitate orientation of the riser joint connector **104**. By way of example without limitation, three orienting members **105** may include a cylindrical or generally cylindrical form extending upwards from a surface of the spider assembly **102**. The orienting members **105** may act as guides to interface the riser joint connector **104** as the riser joint connector **104** is lowered toward the spider assembly **102**, thereby facilitating orientation and/or alignment. In certain embodiments, the orienting members **105** may be fitted with one or more sensors (not shown) to detect position and/or orientation of the riser joint connector **104**, and corresponding signals may be transferred to an information handling system at any suitable location on a vessel or platform by any suitable means, including wired or wireless means.

The spider assembly **102** may include a base **108**. The base **108**, and the spider assembly **102** generally, may be mounted directly or indirectly on a surface of a vessel or platform. For example, the base **108** may be disposed on or proximate to a rig floor. In certain embodiments, the base **108** may include or be coupled to a gimbal mount to facilitate balancing in spite of sea sway.

As mentioned above, certain embodiments of the spider assembly **102** and the riser connector assembly **104** may be fitted with sensors to enable determination of an orientation of the riser connector assembly **104** being positioned within the spider **102** (e.g., via a running tool). As illustrated in FIG. **12**, for example, the riser coupling system **100** may include a radio frequency identification (RFID) based orientation system **190** for aligning a riser joint connector **104** within the riser coupling system **100**. This RFID orientation system **190** may include one or more RFID tags **192** disposed on the riser joint connector **104** and an RFID reader **194** disposed on a section of the spider assembly **102**, with one or more RFID antennae.

Each RFID tag **192** may be an electronic device that absorbs electrical energy from a radio frequency (RF) field. The RFID tag **192** may then use this absorbed energy to broadcast an RF signal containing a unique serial number to the RFID reader **194**. In some embodiments, the RFID tags **192** may include on-board power sources (e.g., batteries) for powering the RFID tags **192** to output their unique RF signals to the reader **194**. The signal output from the RFID tags **192** may be within the 900 MHz frequency band.

The RFID reader **194** may be a device specifically designed to emit RF signals and having an antenna to capture information (i.e., RF signals with serial numbers) from the RFID tags **192**. The RFID reader **194** may respond differently depending on the relative position of the reader **194** to the one or more tags **192**. For example, the RFID reader **194** may slowly capture the RF signal from the RFID tag **192** when the RFID tag **192** and the antenna of the RFID reader **194** are far apart. This may be the case when the riser joint connector **104** is out of alignment with the spider assembly **102**. The RFID reader **194** may quickly capture the signal from the RFID tag **192** when the optimum alignment between the antenna of the reader **194** and the RFID tag **192** is achieved. In the illustrated embodiment, the riser joint connector **104** is oriented about the axis **103** such that one of the RFID tags **192** is as close as possible to the RFID reader **194**, indicating that the riser joint connector **104** is in a desired rotational alignment within the riser coupling system **100**.

The change in speed of response of the RFID reader **194** may be related to the field strength of the signal from the RFID tag **192** and may be directly related to the distance between the RFID tag **192** (transmitter) and the RFID reader **194** (receiver). The RFID reader **194** may take a signal strength measurement, also known as "receiver signal strength indicator" (RSSI), and provide this measurement to a controller **196** (e.g., information handling system) to determine whether the riser joint connector **104** is aligned with the spider assembly **102**. The RSSI may be an electrical signal or computed value of the strength of the RF signal received via the RFID reader **194**. An internally generated signal of the RFID reader **194** may be used to tune the receiver for optimal signal reception. The controller **196** may be communicatively coupled to the RFID reader **194** via a wired or wireless connection, and the controller **196** may also be communicatively coupled to actuators, running tools, or various operable components of the spider assembly **102**.

In some embodiments, the RFID reader **194** may emit a constant power level RF signal, in order to activate any RFID tags **192** that are within range of the RF signal (or RF field). It may be desirable for the RFID reader **192** to emit a constant power signal, since the RF signal strength output from the RFID tags **192** is proportional to both distance and frequency of the signal. In the application described herein, the distance from the antenna of the RFID reader **194** to the RFID tag **192** may be used to locate the angular position of the riser joint connector **104** relative to the RFID reader **194**.

In certain embodiments, the one or more RFID tags **192** may be disposed on a flange of a riser tubular that forms part of the riser joint connector **104**. For example, the RFID tags **192** may be embedded onto a lower riser flange **152**A of a tubular assembly **152** being connected with other tubular assemblies via the riser coupling system **100**. From this position, the RFID tags **192** may react to the RF field from the RFID reader **194**. It may be desirable to embed the RFID tags **192** into only one of two available riser flanges **152**A along the tubular assembly **152**, since RFID tags disposed on two adjacent riser flanges being connected could cause undesirable interference in the signal readings taken by the reader **194**. As illustrated in FIG. **13**, the flange **152**A of the riser joint connector **104** may include three RFID tags **192** disposed thereabout. It should be noted that other numbers (e.g., 1, 2, 4, 5, or 6) of the RFID tags **192** may be disposed about the flange **152**A in other embodiments. In some embodiments, the multiple RFID tags **192** may be generally disposed at equal rotational intervals around the flange **152**A. In other embodiments, such as the illustrated embodiment of FIG. **13**, the RFID tags **192** may be positioned in other arrangements. In still other embodiments, the RFID tags **192** may be disposed along other parts of the riser joint connector **104**.

In some embodiments, a single RFID reader **194** may be used to detect RF signals indicative of proximity of the RFID tags **192** to the reader **194**. The use of one RFID reader **194** may help to maintain a constant power signal emitted in the vicinity of the RFID tags **192** for initiating RF readings. In other embodiments, however, the RFID based orientation system **190** may utilize more than one reader **194**. In the illustrated embodiment, the RFID reader **194** may be disposed on the spider assembly **102**, near where the spider assembly **102** meets the riser joint connector **104**. It should be noted that, in other embodiments, the RFID reader **194** may be positioned or embedded along other portions of the riser coupling system **100** that are rotationally stationary with respect to the spider assembly **102**.

As the riser joint connector **104** is lowered to the spider assembly **102** for makeup, the RFID tags **192** embedded into the edge of the riser flange may begin to respond to the RF field output via the reader **194**. Based on the Received Signal Strength Indication (RSSI) received at the RFID reader **194** in response to the RFID tags **192**, the controller **196** may output a signal to a running tool and/or an orienting device to rotate the riser joint connector **104** about the axis **103**. The tools may rotate the riser joint connector **104** until the riser joint connector **104** is brought into a desirable alignment with the spider assembly **102** based on the signal received at the reader **194**. Upon aligning the riser joint connector **104**, the running tool may then lower the riser joint connector **104** into the spider assembly **102**, and the spider assembly **102** may actuate the riser joint connector **104** to lock the tubular assembly **152** to a lower tubular assembly (not shown).

Once the riser joint connector **104** is locked and lowered into the sea, the RFID tags **192** may shut off in response to the tags **192** being out of range of the RFID transmitter/reader **194**. In embodiments where the electrical power is transferred to the RFID tags **192** via RF signals from the reader **194**, there are no batteries to change out or any concerns over electrical connections to the RFID tags **192** that are then submersed in water. The RFID orientation system **190** may provide accurate detection of the rotational positions of the riser joint connector **104** with respect to the spider assembly **102** before setting the riser joint connector **104** in place and making the riser connection. By sensing the signal strength of embedded RFID tags **192**, the RFID orientation system **190** is able to provide this detection without the use of complicated mechanical means (e.g., gears, pulleys) or electronic encoders for detecting angular rotation and alignment. Once the alignment of the riser joint connector **104** is achieved, the RFID reader **190** may shutoff the RF power transmitter **194**, thereby silencing the RFID tags **192**.

FIG. **2** shows an angular view of the spider assembly **102** prior to receiving the riser joint connector **104** (depicted in FIGS. **1**A and **1**B). The nonlimiting example of the spider assembly **102** with the base **108** includes a generally circular geometry about a central opening **110** configured for running riser sections therethrough. Various alternative embodiments may include any suitable geometry.

FIG. **3**A shows an angular view of one exemplary connector actuation tool **106**, in accordance with certain embodiments of the present disclosure. FIG. **3**B shows a cross-sectional view of the connector actuation tool **106**. The connector actuation tool **106** may include a connection means **112** to allow connection to the base **108** (omitted in FIGS. **3**A, **3**B). As depicted, the connection means **112** may include a number of threaded bolts. However, it should be appreciated that any suitable means of coupling, directly or indirectly, the connector actuation tool **106** to the rest of the spider assembly **102** (omitted in FIGS. **3**A, **3**B) may be employed.

The connector actuation tool **106** may include a dog assembly **114**. The dog assembly **114** may include a dog **116** and a piston assembly **118** configured to move the dog **116**. The piston assembly **118** may include a piston **120**, a piston cavity **122**, one or more hydraulic lines **124** to be fluidly coupled to a hydraulic power supply (not shown), and a bracket **126**. The bracket **126** may be coupled to a support frame **128** and the piston **120** so that the piston **120** remains stationary relative to the support frame **128**. The support frame **128** may include or be coupled to one or more support plates. By way of example without limitation, the support frame **128** may include or be coupled to support plates **130**, **132**, and **134**. The support plate **130** may provide support to the dog **116**.

With suitable hydraulic pressure applied to the piston assembly **118** from the hydraulic power supply (not shown), the piston cavity **122** may be pressurized to move the dog **116** with respect to one or more of the piston **120**, the bracket **126**, the support frame **128**, and the support plate **130**. In the non-limiting example depicted, each of the piston **120**, the bracket **126**, the support frame **128**, and the support plate **130** is adapted to remain stationary though the dog **116** moves. FIGS. **3**A and **3**B depict the dog **116** in an extended state relative to the rest of the connector actuation tool **106**.

The connector actuation tool **106** may include a clamping tool **135**. By way of example without limitation, the clamping tool **135** may include one or more of an upper actuation piston

136, an actuation piston mandrel **138**, and a lower actuation piston **140**. Each of the upper actuation piston **136** and the lower actuation piston **140** may be fluidically coupled to a hydraulic power supply (not shown) and may be moveably coupled to the actuation piston mandrel **138**. With suitable hydraulic pressure applied to the upper and lower actuation pistons **136**, **140**, the upper and lower actuation pistons **136**, **140** may move longitudinally along the actuation piston mandrel **138** toward a middle portion of the actuation piston mandrel **138**. FIGS. **3**A and **3**B depict the upper and lower actuation pistons **136**, **140** in a non-actuated state.

The actuation piston mandrel **138** may be extendable and retractable with respect to the support frame **128**. A motor **142** may be drivingly coupled to the actuation piston mandrel **138** to selectively extend and retract the actuation piston mandrel **138**. By way of example without limitation, the motor **142** may be drivingly coupled to a slide gear **144** and a slide gear rack **146**, which may in turn be coupled to the support plate **134**, the support plate **132**, and the actuation piston mandrel **138**. The support plates **132**, **134** may be moveably coupled to the support frame **128** to extend or retract together with the actuation piston mandrel **138**, while the support frame **128** remains stationary. FIGS. **3**A and **3**B depict the slide gear rack **146**, the support plates **132**, **134**, and the actuation piston mandrel **138** in a retracted state relative to the rest of the connector actuation tool **106**.

The connector actuation tool **106** may include a motor **148**, which may be a torque motor, mounted with the support plate **134** and driving coupled to a splined member **150**. The splined member **150** may also be mounted to extend and retract with the support plate **134**. It should be understood that while one non-limiting example of the connector actuation tool **106** is depicted, alternative embodiments may include suitable variations, including but not limited to, a dog assembly at an upper portion of the connector actuation tool, any suitable number of actuation pistons at any suitable position of the connector actuation tool, any suitable motor arrangements, and the use of electric actuators instead of or in combination with hydraulic actuators.

In certain embodiments, the connector actuation tool **106** may be fitted with one or more sensors (not shown) to detect position, orientation, pressure, and/or other parameters of the connector actuation tool **106**. For nonlimiting example, one or more sensors may detect the positions of the dog **116**, the clamping tool **135**, and/or splined member **150**. Corresponding signals may be transferred to an information handling system at any suitable location on the vessel or platform by any suitable means, including wired or wireless means. In certain embodiments, control lines (not shown) for one or more of the motor **148**, clamping tool **135**, and dog assembly **114** may be feed back to the information handling system by any suitable means.

FIG. **4** shows a cross-sectional view of a riser joint connector **104**, in accordance with certain embodiments of the present disclosure. The riser joint connector **104** may include an upper tubular assembly **152** and a lower tubular assembly **154**, each arranged in end-to-end relation. The upper tubular assembly **152** sometimes may be referenced as a box; the lower tubular assembly **154** may be referenced as a pin.

Certain embodiments may include a seal ring (not shown) between the tubular members **152**, **154**. The upper tubular assembly **152** may include grooves **156** about its lower end. The lower member **154** may include grooves **158** about its upper end. A lock ring **160** may be disposed about the grooves **156**, **158** and may include teeth **160**A, **160**B. The teeth **160**A, **160**B may correspond to the grooves **156**, **158**. The lock ring **160** may be radially expandable and contractible between an unlocked position in which the teeth **160**A, **160**B are spaced from the grooves **156**, **158**, and a locking position in which the lock ring **160** has been forced inwardly so that teeth **160**A, **160**B engage with the grooves **156**, **158** and thereby lock the connection. Thus, the lock ring **160** may be radially moveable between a normally expanded, unlocking position and a radially contracted locking position, which may have an interference fit. In certain embodiments, the lock ring **160** may be split about its circumference so as to normally expand outwardly to its unlocking position. In certain embodiments, the lock ring **160** may include segments joined to one another to cause it to normally assume a radially outward position, but be collapsible to contractible position.

A cam ring **162** may be disposed about the lock ring **160** and may include inner cam surfaces that can slide over surfaces of the lock ring **160**. The cam surfaces of the cam ring **162** may provide a means of forcing the lock ring **160** inward to a locked position. The cam ring **162** may include an upper member **162**A and a lower member **162**B with corresponding lugs **162**A' and **162**B'. The upper member **162**A and the lower member **162**B may be configured as opposing members. The cam ring **162** may be configured so that movement of the upper member **162**A and the lower member **162**B toward each other forces the lock ring **160** inward to a locked position via the inner cam surfaces of the cam ring **162**.

The riser joint connector **104** may include one or more locking members **164**. A given locking member **164** may be adapted to extend through a portion of the cam ring **162** to maintain the upper member **162**A and the lower member **162**B in a locking position where each has been moved toward the other to force the lock ring **160** inward to a locked position. The locking member **164** may include a splined portion **164**A and may extend through a flange **152**A of the upper tubular assembly **152**. The locking member **164** may include a retaining portion **164**B, which may include but not be limited to a lip, to abut the upper member **162**A. The locking member **164** may include a tapered portion **164**C to fit a portion of the upper member **162**A. The locking member **164** may include a threaded portion **164**D to engage the lower member **162**B via threads.

Some embodiments of the riser joint connector **104** may include a secondary locking mechanism, in addition to the cam ring **162** and the lock ring **160**. One such embodiment is illustrated in operation in FIGS. **14**A-**14**D. As illustrated, the riser joint connector **104** may include the upper tubular assembly **152** having the flange **152**A, the lower tubular assembly **154** having the flange **154**A, the lock ring **160**, the cam ring **162**, and a secondary locking mechanism **210** disposed on the cam ring **162**. The secondary locking mechanism **210** may include an outer solid (i.e., continuous) ring **212** with an engagement profile **214** and a split inner ring **216** having a complementary (i.e., matching) engagement profile **218**. In the illustrated embodiment, these engagement profiles **214** and **218** may include rows of interlocking teeth. The outer ring **212** may be disposed on and coupled to the upper member **162**A of the cam ring **162** while the split inner ring **216** is disposed on and coupled to the lower member **162**B of the cam ring **162**. In other embodiments, the outer ring **212** may be disposed on and coupled to the lower member **162**B of the cam ring **162** while the split inner ring **216** is disposed on and coupled to the upper member **162**A of the cam ring **162**.

As illustrated in FIG. **14**A, the split inner ring **216** may be coupled to the cam ring **162** such that the split inner ring **216** is collapsible toward the cam ring **162**. For example, the split inner ring **162** may be coupled to the cam ring **162** via a spring or other biasing member that may be compressed in order to selectively collapse the split inner ring **216**. In some embodiments, the connector actuation tool **106** may include a manipulator section **220** (similar to clamping tool **135** described above) with a built in shoulder **222** for collapsing the split inner ring **216**. When the manipulator sections **220** of the connector actuation tool **106** are actuated toward the riser joint connector **104**, the shoulder **222** on each of the manipulator sections **220** may contact the split inner ring **216** and apply a radial force inward. This radial force from the shoulder **222** of the manipulator section **220** may collapse the split inner ring **216** against the cam ring **162**. This collapse of the split inner ring **216** is illustrated in detail in FIG. **14**B.

Upon its collapse, the split inner ring **216** may have a smaller outer diameter than the outer ring **212**, as shown in FIG. **14**B. At this point, the manipulator section **220** may be engaged with the cam ring **162**. For example, the illustrated manipulator section **220** may include a projection **224** to engage a depression **226** formed in the upper member **162**A of the cam ring **162**, as well as a projection **228** to engage a depression **230** formed in the lower member **162**B of the cam ring **162**. In other embodiments, different types of engagement features may be used at this interface (e.g., piston sections of the manipulator **220** to be engaged with lugs on the cam ring **162**). Once engaged with the cam ring **162**, the manipulator section **220** may be actuated to force the cam ring members axially toward one another. As shown in FIG. **14**C, this movement of the cam ring members **162**A and **162**B toward each other may be performed without the split inner ring **216** contacting the outer ring **212** of the secondary locking mechanism (e.g., due to the difference in outer diameter of the collapsed inner ring **216** and inner diameter of the outer ring **212**).

Once the manipulator section **220** actuates the cam ring members **162** together, this locks the two riser flanges **152**A and **154**A together via the riser joint connector **104**. As described above, for example, the cam ring members **162**A and **162**B may force the lock ring **160** into engagement with both the upper tubular assembly **152** and the lower tubular assembly **154**. As shown in FIG. **14**C, the cam ring members **162** may be positioned relative to one another such that the outer ring **212** and the split inner ring **216** of the secondary locking mechanism **210** are overlapping each other (without touching). Thus, in this position the split inner ring **216** may be disposed at least partially inside the outer ring **212**.

When the manipulator sections **220** are retracted from the riser joint connector **104**, the split inner ring **216** may expand back outward (e.g., via a biasing feature) to engage with the outer ring **212**, as shown in FIG. **14**D. The split inner ring **216** may be forced into a locking profile of the outer ring **212** (e.g., by seating the profile **218** into the corresponding profile **214**), thereby closing the secondary locking mechanism **210** to lock the riser joint connector **104** in place. The secondary locking mechanism **210** may effectively lock the riser joint connector **104** in place such that the lock ring **160** cannot disengage with the tubular assemblies **152** and **154** in response to vibrations. Thus, the secondary locking mechanism **210** may ensure that the riser joint connector **104** does not unlock due to vibrations or other external forces experienced at the connection.

As described above, the secondary locking mechanism **210** of FIGS. **14**A-**14**D may be closed to lock the riser joint connector **104** via the same actuation tool **106** (e.g., manipulator **220**) used to actuate the primary cam ring **162** and lock ring **160** into place. This enables a second (redundant) lock to be established between the tubular assemblies **152** and **154** without the use of an additional manipulator tool for locking/unlocking the secondary locking mechanism **210**. The use of such an additional tool could lead to undesirable system complexity. For example, other tools for actuating secondary locks might use ratcheting mechanisms to close the second lock, and such tools can be difficult to manufacture, use an undesirable amount of locking force, and wear relatively easy. The illustrated secondary locking mechanism **210**, however, utilizes a simpler, more reliable lock design that can be actuated using a simple mechanical shoulder built into the manipulator section **220**.

Turning back to FIG. **4**, the riser joint connector **104** may include one or more auxiliary lines **166**. For example, the auxiliary lines **166** may include one or more of hydraulic lines, choke lines, kill lines, and boost lines. The auxiliary lines **166** may extend through the flange **152**A and a flange **154**A of the lower tubular assembly **154**. The auxiliary lines **166** may be adapted to mate between the flanges **152**A, **154**A, for example, by way of a stab fit.

The riser joint connector **104** may include one or more connector orientation guides **168**. A given connector orientation guide **168** may be disposed about a lower portion of the riser joint connector **104**. By way of example without limitation, the connector orientation guide **168** may be coupled to the flange **154**A. The connector orientation guide **168** may include one or more tapered surfaces **168**A formed to, at least in part, orient at least a portion of the riser joint connector **104** when interfacing one of the dog assemblies (e.g., **114** of FIGS. **3**A and **3**B). When the dog assembly **114** described above contacts one or more of the tapered surfaces **168**A of the connector orientation guide **168**, the one or more tapered surfaces **168**A may facilitate axial alignment and/or rotational orientation of the riser joint connector **104** by biasing the riser joint connector **104** toward a predetermined position with respect to the dog assembly. In certain embodiments, the connector orientation guide **168** may provide a first stage of an orientation process to orient the lower tubular assembly **154**.

The riser joint connector **104** may include one or more orientation guides **170**. In certain embodiments, the one or more orientation guides **170** may provide a second stage of an orientation process. A given orientation guide **170** may be disposed about a lower portion of the riser joint connector **104**. By way of example without limitation, the orientation guide **170** may be formed in the flange **154**A. The orientation guide **170** may include a recess, cavity or other surfaces adapted to mate with a corresponding guide pin **172** (depicted in FIG. **5**).

FIG. **5** shows a cross-sectional view of landing a riser section, which may include the lower tubular assembly **154**, in the spider assembly **102**, in accordance with certain embodiments of the present disclosure. In the example landed state shown, the dogs **116** have been extended to retain the tubular assembly **154**, and the two-stage orientation features have oriented the lower tubular assembly **154**. Specifically, the connector orientation guide **168** has already facilitated axial alignment and/or rotational orientation of the lower tubular assembly **154**, and one or more of the dog assemblies **114** may include a guide pin **172** extending to mate with the orientation guide **170** to ensure a final desired orientation.

A running tool **174** may be adapted to engage, lift, and lower the lower tubular assembly **154** into the spider assembly **102**. In certain embodiments, the running tool **174** may be adapted to also test the auxiliary lines **166**. For example, the running tool **174** may pressure test choke and kill lines coupled below the lower tubular assembly **154**.

In certain embodiments, one or more of the running tool **174**, the tubular assembly **154**, and auxiliary lines **166** may be fitted with one or more sensors (not shown) to detect position, orientation, pressure, and/or other parameters associated with said components. Corresponding signals may be transferred to an information handling system at any suitable location on the vessel or platform by any suitable means, including wired or wireless means.

FIG. **6** shows a cross-sectional view of running the upper tubular assembly **152** to the landed lower tubular assembly **154**, in accordance with certain embodiments of the present disclosure. The running tool **174** may be used to engage, lift, and lower the upper tubular assembly **152**. The upper tubular assembly **152** may be lowered onto a stab nose **178** of the lower tubular assembly **154**.

In certain embodiments, the running tool **174** may include one or more sensors **176** to facilitate proper alignment and/or orientation of the upper tubular assembly **152**. The one or more sensors **176** may be located at any suitable positions on the running tool **174**. In certain embodiments, the tubular member **152** may be fitted with one or more sensors (not shown) to detect position, orientation, pressure, and/or other parameters of the tubular member **152**. Corresponding signals may be transferred to an information handling system at any suitable location on the vessel or platform by any suitable means, including wired or wireless means.

FIG. **7** shows a cross-sectional view of orienting the upper tubular assembly **152** with respect to lower tubular assembly **154**, in accordance with certain embodiments of the present disclosure. It should be understood that orienting the upper tubular assembly **152** may be performed at any suitable stage of the lowering process, or throughout the lower process.

FIG. **8** shows a cross-sectional view of the upper tubular assembly **152** landed, in accordance with certain embodiments of the present disclosure.

FIG. **9** shows a cross-sectional view of the connector actuation tool **106** engaging the riser joint connector **104** prior to locking the riser joint connector **104**, in accordance with certain embodiments of the present disclosure. As depicted, the actuation piston mandrel **138** may be extended toward the riser joint connector **104**. The upper actuation piston **136** may engage the lug **162**A' and/or an adjacent groove of the cam ring **162**. Likewise, the lower actuation piston **140** may engage the lug **162**B' and/or an adjacent groove of the cam ring **162**. The splined member **150** may also be extended toward the riser joint connector **104**. As depicted, the splined member **150** may engage the locking member **164**. In various embodiments, the actuation piston mandrel **138** and the splined member **150** may be extended simultaneously or at different times.

FIG. **10** shows a cross-sectional view of the connector actuation tool **106** locking the riser joint connector **104**, in accordance with certain embodiments of the present disclosure. As depicted, with suitable hydraulic pressure having been applied to the upper and lower actuation pistons **136**, **140**, the upper and lower actuation pistons **136**, **140** moved longitudinally along the actuation piston mandrel **138** toward a middle portion of the actuation piston mandrel **138**. The upper member **162**A and the lower member **162**B of the cam ring **162** are thereby forced toward one another, which may act as a clamp that in turn forces the lock ring **160** inward to a locked position via the inner cam surfaces of the cam ring **162**. As depicted, the locking member **164** may be in a locked position after the motor **148** has driven the splined member **150**, which in turn has driven the locking member **164** into the locked position to lock the cam ring **162** in a clamped position. In various embodiments, the locking member **164** may be actuated into the locked position as the cam ring **162** transitions to a locked position or at a different time.

FIG. **11** shows a cross-sectional view of the connector actuation tool **106** retracted, in accordance with certain embodiments of the present disclosure. From that position, the running tool **174** (depicted in previous figures) may engage the riser joint connector **104** and lift the riser joint connector **104** away from the guide pin **172**. The dogs **114** may be retracted, the riser joint connector **104** may be lowered passed the spider assembly **102**, and the process of landing a next lower tubular may be repeated. It should be understood that a dismantling process may entail reverses the process described herein.

Some embodiments of the riser joint connector **104** may feature a modular design that enables a coupling used to lock the tubular assemblies **152**/**154** together to be selectively removable from the tubular assemblies. An embodiment of one such modular riser joint connector assembly **250** is illustrated in FIGS. **16**A-**16**D. In this embodiment, the riser joint connector assembly **250** includes a coupling **252** that can be selectively disposed on or removed from one or both of the upper and lower tubular assemblies. In the illustrated embodiment, the coupling **252** is shown being selectively engaged and disengaged with the upper tubular assembly **152**. The coupling **252** may include at least the lock ring **160** and the cam ring **162**. In some embodiments, the coupling **252** may include additional components such as, for example, the secondary locking mechanism **210** described above with reference to FIGS. **14**A-**14**D. Other components or arrangements of such components used to lock adjacent tubular assemblies together may form the modular coupling **252** in other embodiments.

To position and secure the coupling **252** onto the upper tubular assembly **152**, the coupling **252** may be positioned proximate an end of the upper tubular assembly **152**, as shown in FIG. **16**A. The coupling **252** may be rotated about an axis **254** to align a projection **256** extending radially outward from the upper tubular assembly **152** into a corresponding slot **258** formed through the coupling **252**. As illustrated, the coupling **252** may be equipped with multiple such slots **258** to accommodate a number of complementary projections **256** extending from the upper tubular assembly **152**. In the illustrated embodiment, these projections **256** may include an extended tooth or extended portions of a tooth **260** used to engage the lock ring **160** when the lock ring **160** is sealed onto the tubular assembly **152**. As illustrated, the other teeth **262** on the tubular assembly **152** that are used to engage the corresponding teeth on the lock ring **160** may be shorter (i.e., extending a shorter distance radially outward) than the extended tooth **260**. In other embodiments, the tubular assembly **152** may include two or more extended teeth **260** to be received into the slots **258** formed within the coupling **252**.

FIG. **15** illustrates a cross-sectional view of the interface between the projections **256** of the tubular assembly **152** and the corresponding slots **258** in the coupling **252**. As illustrated, the slots **258** may be formed in the lock ring **160**. FIG. **16**B illustrates the extended tooth projection **256** being positioned within the corresponding slot **258** of the lock ring **160**. Once the projection **256** is received through the slot **258** in the coupling **252**, the coupling **252** may be moved further onto the tubular assembly **152** such that the projection **256** moves past the slot **258** and into the engagement portion of the lock ring **160**. The "engagement portion" of the lock ring may include the toothed profile of the locking mechanism **160**, as illustrated. That is, the coupling **252** may be positioned over the tubular assembly **152** such that the projection **256** enters the coupling **252** through the appropriately oriented slot **258** and then passes through the slot **258** into a toothed profile that enables rotation of the coupling **252** with respect to the tubular assembly **152**.

From this position, the coupling **252** may be rotated about the axis **254**, with respect to the tubular assembly **152**, to align other components of the coupling **252** and the tubular assembly **152**. For example, in the illustrated embodiment of FIG. **16**C, the coupling **252** may be rotated with respect to the tubular assembly **152** to align a portion **263** of the tubular assembly **152** with another slot **264** formed through the coupling **252**. The slot **264** may be radially offset from the other one or more slots **258** formed through the lock ring **160**. Similarly, the portion **263** of the tubular assembly **152** may be radially offset from the one or more projections **256** extending from the tubular assembly **152**. In the illustrated embodiment, the portion **263** of the tubular assembly **152** includes a channel or slot **266** through which a locking mechanism may be received, and a shortened section **268** of the lock ring **160** may define the additional slot **264** within the coupling **252**.

Once the coupling **252** is rotated so that the projection **256** is no longer aligned with the corresponding slot **258**, the coupling **252** is generally secured to the tubular assembly **152**. To ensure that the coupling **252** stays securely fastened onto the tubular assembly **152**, the modular riser joint connector assembly **250** may further include a removable locking pin **270** that can be disposed at least partially through the portion **263** of the tubular assembly **152** and through the slot **264**. This locking pin **270** is disposed in the locking position in the illustrated embodiment of FIG. **16**C. The locking pin **270** may be secured via a retainer bolt **272** disposed through an opening in the tubular assembly **152** and screwed into the locking pin **270**. When the locking pin **270** is secured in this position, it may prevent the coupling **252** from rotating with the respect to the tubular assembly **152**. Thus, the locking pin **270** may be used to selectively secure the coupling **252** to the end of the tubular assembly **152** as shown.

As described above, it is desirable to make the coupling **252** selectively removable from the tubular assembly **152**. In the event that the coupling **252** malfunctions during the automated coupling process, an operator may remove the retainer bolt **272** and the locking pin **270**, rotate the coupling **252** so that the projections **256** once again align with the slots **258** in the coupling **252**, and slide the coupling **252** off the tubular assembly **152**. This removal of the locking pin **270** and the coupling **252** is illustrated in FIG. **16**D. The defective coupling may then be replaced with a new coupling **252**, without an operator having to remove or dispose of the entire tubular assembly **152**.

In some embodiments, the coupling **252** may incorporate a spreader wedge to ensure that the cam ring **162** can be opened. This may keep the coupling **252** from becoming stuck in the locked position, so that the coupling **252** may later be removed from the tubular assembly **152** as desired.

The disclosed modular riser joint connector assembly **250** may allow an end user to quickly remove, replace, and/or service the coupling **252**. The user would not have to remove the entire tubular assembly **152** along with the coupling **252**, since the coupling **252** is removable from the tubular assembly **152**. This may save the end user time in performing service, repairs, and replacements of the riser parts. In the event that a flange (e.g., **152**A) of the tubular assembly **152** becomes damaged, the coupling **252** may be removed from the unusable tubular assembly **152** and repositioned on a new tubular assembly **152**. This may enable the operators to service the riser connections with fewer total parts than would be necessary if the coupling and the tubular assembly were permanently attached.

Accordingly, certain embodiments of the present disclosure allow for hands-free riser section coupling systems and methods. Certain embodiments allow for minimal and remote operator involvement. As a result, certain embodiments provide safety improvements in part by eliminating or significantly reducing direct operator involvement that would otherwise expose an operator to risks of injury, fatigue, and increased potential for human error. Moreover, certain embodiments allow for increased speed and efficiency in the riser section coupling process. Certain embodiments allow for lighter coupling components, for example, by eliminating or significantly reducing the need for heavy bolts and flanges. This may save material usage and augment the speed and efficiency of the riser section coupling process.

Therefore, the present disclosure is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present disclosure may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Even though the figures depict embodiments of the present disclosure in a particular orientation, it should be understood by those skilled in the art that embodiments of the present disclosure are well suited for use in a variety of orientations. Accordingly, it should be understood by those skilled in the art that the use of directional terms such as above, below, upper, lower, upward, downward and the like are used in relation to the illustrative embodiments as they are depicted in the figures, the upward direction being toward the top of the corresponding figure and the downward direction being toward the bottom of the corresponding figure.

Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present disclosure. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. The indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that the particular article introduces; and subsequent use of the definite article "the" is not intended to negate that meaning.

What is claimed is:

1. A riser coupling system, comprising:

a riser joint connector comprising:

- a first tubular assembly;
- a second tubular assembly;
- a cam ring having an upper member and a lower member, wherein the upper member and the lower member are adjustable to retain the first tubular assembly and the second tubular assembly together;
- a lock ring, wherein movement of the upper member of the cam ring and the lower member of the cam ring toward each other engages the lock ring to secure the first tubular assembly to the second tubular assembly;
- a locking member adjustable to retain the cam ring in a locked position; and
- a radio frequency identification (RFID) tag disposed on the first tubular assembly;

a spider assembly to receive the riser joint connector, the spider assembly comprising a connector actuation tool, wherein the connector actuation tool comprises:

- a dog assembly configured to selectively extend a dog to engage the riser joint connector;
- a clamping tool to actuate the upper cam ring member and the lower cam ring member of the riser joint connector;
- a splined member to actuate the locking member; and
- a RFID reader for detecting a signal from the RFID tag on the first tubular assembly; and

a running tool configured to move the first tubular assembly into orientation with the second tubular assembly based on the signal detected via the RFID reader.

2. The riser coupling system of claim **1**, further comprising a controller communicatively coupled to the RFID reader to determine whether the first tubular assembly is in alignment with the spider assembly based on the signal detected via the RFID reader.

3. The riser coupling system of claim **2**, wherein the controller is communicatively coupled to the running tool to output a control signal for the running tool to lower the first tubular assembly into engagement with the second tubular assembly when the first tubular assembly is in alignment with the spider assembly.

4. The riser coupling system of claim **2**, wherein the controller is communicatively coupled to the connector actuation tool to output a control signal to the connector actuation tool for coupling the first tubular assembly to the second tubular assembly when the first tubular assembly is in alignment with the spider assembly.

5. The riser coupling system of claim **1**, wherein the RFID tag is disposed on a flange of the first tubular assembly.

6. The riser coupling system of claim **1**, further comprising a plurality of RFID tags disposed on the first tubular assembly.

7. The riser coupling system of claim **1**, wherein the RFID reader is operable to emit a constant power level radio frequency signal to the RFID tag.

8. The riser coupling system of claim **1**, wherein the spider assembly is remotely operated.

9. The riser coupling system of claim **1**, wherein the clamping tool comprises an upper actuation piston, an actuation piston mandrel and a lower actuation piston.

10. The riser coupling system of claim **1**, wherein the dog assembly further comprises a piston assembly, wherein the piston assembly is operable to extend the dog to engage the riser joint connector to retain the second tubular assembly in the spider assembly.

11. A riser coupling system, comprising:

a riser joint connector comprising:

a first tubular assembly coupled to a second tubular assembly;

a cam ring having an upper member and a lower member, wherein the upper member and the lower member are adjustable to retain the first tubular assembly and the second tubular assembly together;

a lock ring, wherein movement of the upper member and the lower member toward each other engages the lock ring to secure the first tubular assembly to the second tubular assembly; and

a radio frequency identification (RFID) tag disposed on the first tubular assembly;

a spider assembly having a connector actuation tool for coupling the first tubular assembly with a second tubular assembly, wherein the spider assembly receives the riser joint connector and wherein the connector actuation tool comprises:

a dog assembly, wherein the dog assembly selectively extends a dog to engage the riser joint connector;

a clamping tool, wherein the clamping tool couples the first tubular assembly and the second tubular assembly; and

a splined member to actuate a locking member of the riser joint connector;

a RFID reader disposed on the spider assembly for detecting a signal emitted from the RFID tag on the first tubular assembly; and

a controller communicatively coupled to the RFID reader to determine an angular orientation of the first tubular assembly with respect to the second tubular assembly based on the signal detected via the RFID reader.

12. The riser coupling system of claim **11**, further comprising a running tool communicatively coupled to the controller for orienting the first tubular assembly into an aligned angular orientation with respect to the spider assembly.

13. The riser coupling system of claim **11**, wherein the RFID tag is disposed on a flange of the first tubular assembly.

14. The riser coupling system of claim **11**, further comprising a plurality of RFID tags disposed on the first tubular assembly.

15. The riser coupling system of claim **11**, wherein the RFID reader is operable to emit a constant power level radio frequency signal to the RFID tag.

16. A method, comprising:

disposing a riser joint connector proximate a spider assembly comprising a connector actuation tool, wherein the riser joint connector comprises a first tubular assembly having a radio frequency identification (RFID) tag disposed thereon;

detecting a signal emitted from the RFID tag via a RFID reader disposed on the spider assembly;

determining an angular orientation of the first tubular assembly relative to a second tubular assembly based on the signal detected by the RFID reader;

rotating the first tubular assembly into alignment with the second tubular assembly via a running tool based on the determined angular orientation; and

actuating the riser joint connector via the connector actuation tool to couple the first tubular assembly with the second tubular assembly.

17. The method of claim **16**, wherein the riser joint connector further comprises a cam ring having an upper member and a lower member, and a lock ring; further comprising engaging the cam ring of the riser joint connector via the connector actuation tool, and actuating the upper member and the lower member of the cam ring toward each other via the connector actuation tool to secure the lock ring against the first and second tubular assemblies.

18. The method of claim **17**, further comprising actuating a locking member of the riser joint connector via a splined member of the connector actuation tool.

19. The method of claim **16**, further comprising outputting a control signal from a controller coupled to the RFID reader to the running tool to rotate the first tubular assembly.

20. The method of claim **16**, further comprising emitting a constant power level radio frequency signal from the RFID reader to the RFID tag.

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